



July 26, 2018

Mr. Russell Fish  
Office of Remediation 3LC20  
U.S. Environmental Protection Agency  
1650 Arch Street  
Philadelphia, PA 19103-2029

Regarding: RCRA Facility Investigation Phase IV Work Plan  
Honeywell Delaware Valley Works  
Claymont, Delaware

Dear Russell:

Enclosed are three (3) copies of the RCRA Facility Investigation Phase IV Work Plan for the Honeywell International Inc. Honeywell Delaware Valley Works in Claymont, Delaware. Please contact Steve Coladonato at 302-791-6738 or Richard Karr at 610-877-6154 if you have questions or require further information.

Sincerely,

**Wood Environment & Infrastructure Solutions, Inc.**

John P. Mihalich, P.G.  
Associate Geologist

Richard C. Karr  
Branch Mgr./Principal

cc w/enc: Larry Matson – DNREC (1 copy)

cc w/o enc: Steve Coladonato – Honeywell  
Russell Davis – Honeywell  
Nelson Johnson – Arnold & Porter



## **HONEYWELL DELAWARE VALLEY WORKS CLAYMONT, DELAWARE**

*Prepared for*

**Honeywell**

115 Tabor Road  
Morris Plains, NJ 07950

*Prepared by*

**wood.**

Wood Environment & Infrastructure Solutions, Inc.  
751 Arbor Way, Suite 180  
Blue Bell, PA 19422

**July 2018**

## **CERTIFICATION**

I certify that the information contained in or accompanying the RFI Phase IV Work Plan for the Delaware Valley Works in Claymont, Delaware is true, accurate, and complete.

As to the identified portion of the RFI Phase IV Work Plan for which I cannot personally verify its accuracy, I certify under penalty of law that this Work Plan and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fines and imprisonment for knowing violations.

**Honeywell International Inc.**



---

Steven Coladonato

Remediation Manager

## TABLE OF CONTENTS

<b>1.0</b>	<b>INTRODUCTION .....</b>	<b>1</b>
1.1	WORK PLAN OBJECTIVES .....	1
1.2	WORKPLAN ORGANIZATION .....	2
<b>2.0</b>	<b>BACKGROUND .....</b>	<b>3</b>
2.1	SITE DESCRIPTION .....	3
2.2	SWMU/AOC DESCRIPTIONS.....	3
2.3	REGULATORY HISTORY.....	3
2.4	PREVIOUS INVESTIGATIONS .....	6
2.5	PHYSICAL SETTING.....	6
	<i>Regional Geology.....</i>	<i>6</i>
	<i>Local Geology .....</i>	<i>6</i>
	<i>Regional Hydrogeology.....</i>	<i>7</i>
	<i>Local Hydrogeology .....</i>	<i>7</i>
	<i>Surface Water.....</i>	<i>8</i>
2.6	CONCEPTUAL SITE MODEL .....	8
<b>3.0</b>	<b>SCOPE OF WORK.....</b>	<b>10</b>
3.1	SYNOPTIC ROUND OF WATER LEVELS .....	10
3.2	BACKGROUND RESEARCH.....	11
3.3	SURFACE GEOPHYSICAL SURVEY.....	11
3.4	MW-6 VOCS SOIL BORINGS.....	11
3.6	MONITORING WELL INSTALLATION.....	14
3.7	GROUNDWATER SAMPLING .....	14
3.8	SOIL VAPOR INTRUSION .....	16
	<i>Existing Data Evaluation .....</i>	<i>17</i>
	<i>Sample Collection .....</i>	<i>18</i>
	<i>Data Evaluation.....</i>	<i>19</i>

<b>4.0</b>	<b>REFERENCED DOCUMENTS.....</b>	<b>21</b>
<b>5.0</b>	<b>REPORTING.....</b>	<b>22</b>
<b>6.0</b>	<b>PROJECT MANAGEMENT PLAN .....</b>	<b>23</b>
<b>6.1</b>	<b>PROJECT ORGANIZATION AND RESPONSIBILITIES .....</b>	<b>23</b>
<b>6.2</b>	<b>PROJECT SCHEDULE.....</b>	<b>23</b>
<b>7.0</b>	<b>REFERENCES.....</b>	<b>25</b>

## **Tables**

Table 1	Summary of Samples and Chemical Analysis
Table 2	VISL Results (within text)

## **Figures**

Figure 1	Site Location Map
Figure 2	Site Plan
Figure 3	MW-6 VOCs Investigation Area
Figure 4	Areas 5 and 6 Investigation Area
Figure 5	Occupied Buildings
Figure 6	Project Organization Chart
Figure 7	Project Schedule

## **Appendices**

Appendix A	QAPP Update Pages
Appendix B	SAMP Update Pages
Appendix C	HASP Update Pages
Appendix D	VISL Outputs

## 1.0 INTRODUCTION

Wood Environment & Infrastructure Solutions, Inc. (Wood), on behalf of Honeywell International Inc. (Honeywell), is submitting this Phase IV Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Work Plan (the Work Plan) for the Honeywell Delaware Valley Works (DVW) in Claymont, Delaware (the Site). This Work Plan is being submitted to the United States Environmental Protection Agency (USEPA) in response to the USEPA's request for work plans as stated in its May 22, 2018 comment letter:

- Provide a work plan to locate and delineate the previously unidentified source of volatile organic compounds (VOCs) in the vicinity of well MW-6;
- Provide a work plan to completely delineate the groundwater plume migrating from Areas 5 and 6; and
- Provide a work plan to assess soil vapor intrusion within occupied structures as referenced in the RFI Report.

The USEPA's May 22, 2018 request is based recommendations for further investigation summarized in the April 12, 2016 RFI Report,

### 1.1 WORK PLAN OBJECTIVES

The overall objectives of the RFI, as agreed to between the USEPA and Honeywell during a meeting on August 28, 2014 and as stated in the June 16, 2015 RFI Work Plan approved by USEPA, are:

1. Collection of remaining data necessary to delineate waste and the release of hazardous constituents at Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs), necessary to evaluate human health and environmental risk, and to support selection of corrective measures at SWMUs as noted in the March 2014 Corrective Action Framework Technical Memorandum;
2. Collection of groundwater data necessary to support a Current Human Exposures Under Control Environmental Indicator (EI) status of "Yes";
3. Collection of groundwater data necessary to support a Migration of Contaminated Groundwater Under Control EI status of "Yes"; and,
4. Completion of a Human Health Risk Assessment (RA) to provide the decisional basis for USEPA selection of corrective measures.

Honeywell's commitment to the RCRA Lean program was reiterated during a phone call between the USEPA and Honeywell on July 10, 2017. During a meeting between the USEPA and Honeywell on September 21, 2017, the USEPA requested the development of Corrective Action Objectives (CAOs) using USEPA's RCRA Facilities Investigation Remedy Selection Track (FIRST) Toolbox for Corrective Action. The USEPA and Honeywell agreed to use the RCRA FIRST Toolbox for all areas of investigation, starting with SWMU 9.

Appropriate interim measures for SWMU 9 were discussed during the September 21, 2017 meeting.

The data collection activities proposed in this Work Plan will be used to support these overall objectives, as applicable, as well as the following objectives in response to the USEPA's May 22, 2018 request:

1. Locate and delineate the previously unidentified source of VOCs in the vicinity of well MW-6;
2. Delineate the groundwater plume migrating from Areas 5 and 6; and
3. Assess soil vapor intrusion within occupied structures at the Site.

This Work Plan references the following documents.

1. The RFI Work Plan, Rev. 4, which includes the following four parts and was approved by USEPA on July 7, 2015:
  - a. Part I, the RFI Work Plan;
  - b. Part II, the Sampling, Analysis, and Monitoring Plan (SAMP);
  - c. Part III, the Data Management Plan (DMP); and
  - d. Part IV, the Community Relations Plan (CRP)
2. The Quality Assurance Project Plan (QAPP), which was submitted to USEPA in April 2014. The content of the QAPP is now consistent with the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP), and was prepared as a separate stand-alone document. Updates to the QAPP were submitted to the USEPA via email on January 20, 2015.
3. The Health & Safety Plan (HASP), which was last updated in 2015 prior to the RFI.

These documents, and updates to these documents as necessary for purposes of this Work Plan, are discussed in **Section 4.0**.

## **1.2 WORKPLAN ORGANIZATION**

The report is organized as follows:

- **Section 1.0** provides an introduction to this Work Plan;
- **Section 2.0** provides background information;
- **Section 3.0** provides a description of the scope of work;
- **Section 4.0** provides a summary of the referenced documents;
- **Section 5.0** provides a description of reporting as a result of the proposed scope of work;
- **Section 6.0** provides the project management plan; and
- **Section 7.0** lists the referenced documents.

## 2.0 BACKGROUND

### 2.1 SITE DESCRIPTION

The DVW is comprised of several parcels totaling 34 acres straddling the Delaware – Pennsylvania state line in an area where heavy industries of chemical manufacturing, refining, and steelmaking have been ongoing for decades (**Figure 1**). Two-thirds of the DVW is located in Pennsylvania with the remainder situated in Delaware. The Site itself has been utilized for manufacturing a variety of chemicals since it was established nearly 100 years ago. The Site is currently an active chemical manufacturing operation, producing boron trifluoride (BF<sub>3</sub>) and fluorosulfonic acid (FSA). The DVW is surrounded by the Marcus Hook Industrial Complex (MHIC) (f.k.a Sunoco, Inc. – Marcus Hook Refinery or Sun Refining & Marketing Co. – Marcus Hook) to the north and south and Braskem to the east. An Amtrak rail right-of-way forms the northern property boundary, separating the Site from MHIC property in the north, and Philadelphia Pike (Route 13) forms the southern boundary. MHIC and the Chemtrade (f.k.a. General Chemical Corporation or GCC) property are located across Philadelphia Pike to the south. A separate 16-acre parcel of the DVW property, SWMU 9, is located on the Delaware River east and south of the Chemtrade property.

### 2.2 SWMU/AOC DESCRIPTIONS

There are 13 SWMUs and two AOCs on the DVW and SWMU 9 (located on a separate parcel), that are subject to the RFI (see **Figure 2** for SWMU, AOC, and existing monitoring well locations). Detailed descriptions of each SWMU and AOC were presented in the June 2015 RFI Work Plan and April 2016 RFI Report.

### 2.3 REGULATORY HISTORY

The DVW has been an industrial facility for nearly 100 years. Over its history, the DVW manufactured various chemical products including pesticides, organic and inorganic acids, and specialty chemicals. Currently, the DVW produces two materials: BF<sub>3</sub>, a reaction catalyst used in a variety of process applications, and FSA.

Based on the treatment, storage, and disposal of hazardous waste at the DVW, a Notification of Hazardous Waste Activity was submitted to USEPA on July 28, 1980. This submittal triggered several notifications/events, including the following:

- On November 11, 1980, Allied Chemical Corporation submitted a RCRA Part A Hazardous Waste Permit Application to USEPA for the DVW.
- On March 11, 1982, USEPA acknowledged that the DVW qualified for Interim Status.
- On August 15, 1983, AlliedSignal submitted a RCRA Part B Permit Application to the Pennsylvania Department of Environmental Resources (PADER), currently known as the Pennsylvania Department of Environmental Protection (PADEP).



- On September 5, 1985, the Part B Permit Application for the DVW was withdrawn.
- In June 1986, AlliedSignal completed a RCRA Facility Assessment (RFA) in which 14 SWMUs and one AOC that are part of this study were identified on what is now DVW property.
- In 1999, USEPA Region III issued an Administrative Order on Consent (ACO) to GCC to conduct a RFI on property that included property later sold to Honeywell.
- On December 15, 1999, USEPA Region III issued a letter requesting that Honeywell enter the RCRA Facility Lead Corrective Action Program. Honeywell accepted USEPA's request by letter dated December 15, 1999.
- In 2003, Honeywell conducted a Phase I RFI at eight of the SWMUs (9, 13, 14, 15, 17, 18, 19, and 20) identified at the DVW in accordance with the Facility Lead RCRA Corrective Action Revised Workplan dated October 2002. In addition, in 2003, GCC conducted a RFI at SWMUs and AOCs located on portions of the DVW that would eventually be re-acquired by Honeywell (SWMUs 16, 21/22/30, 23, 27 and AOC 3).
- In 2004 and 2005, Honeywell conducted a Phase II RFI that included additional SWMU specific assessment activities at SWMUs 13, 14, 15, 19, and 20 located on the portions of the DVW owned by Honeywell at that time and monitoring well installation for both SWMU specific and site-wide groundwater quality assessments. The Phase II RFI activities were performed in accordance with the USEPA approved Workplan Addendum dated June 2004 and revised based on the August 2004 USEPA comments to the Workplan.
- In 2005, Honeywell acquired the GCC North Plant, part of the GCC property at the DVW.
- In 2008 and 2009, Honeywell conducted an investigation of AOC 16NP as part of the ongoing RFI after discovery of debris and hazardous constituents during installation of a weather tower foundation.
- On September 2, 2011, Honeywell signed the ACO. The ACO included, among other things, participation with GCC in the development and implementation of Interim Remedial Measures in the sluiceway on the GCC property and for sediments in the Delaware River adjacent Honeywell's property and GCC property.
- In December 2011, Honeywell submitted the RFI Work Plan for the DVW.
- On March 31, 2014, Honeywell submitted the Corrective Action Framework Technical Memorandum to USEPA for the DVW, which was used as the partial basis for revising this Work Plan. Several COC "surrogates" were selected from historical soils and groundwater RFI data and screened to identify where concentrations exceeded the current Regional Screening Levels (RSLs). The results of this screening were used to identify SWMUs and AOCs where a corrective action (CA) can be identified without collection of further RFI data, and where RFI work remains to be completed.
- On August 28, 2014, Honeywell met with the USEPA to present the Source Assessment Methodology findings, and to gain approval for the investigative actions. Three example SWMUs were presented with their data usability results, chemicals

of potential concern (COPC), and soil source evaluations and graphic depictions of the evolution of the understanding of the limits of “waste”. These results were the result of a process developed to define the limits of each SWMU or AOC and define the remaining scope of work necessary to complete the RFI.

- Following the August 28, 2014 meeting, the USEPA was provided with draft proposed work scope packages for each SWMU and AOC, and following review, indicated its concurrence with all proposed draft work scopes.
- On June 16, 2015, Honeywell submitted a RFI Work Plan which addressed 14 SWMUs, two AOCs, and Site-wide groundwater. The work plan was approved by the USEPA in a letter dated July 7, 2015 and implemented from July through October 2015. The RFI Report summarizing the work completed was submitted to USEPA on April 12, 2016.
- On September 21, 2017, Honeywell met with the USEPA and discussed an interim measure for SWMU 9. A CAO matrix for SWMU 9 developed using RCRA FIRST Tool 7 was submitted to the USEPA on November 14, 2017.
- On May 11, 2018, Honeywell submitted a SWMU 9 Data Summary Report developed using RCRA FIRST Tool 4 to USEPA.

The April 12, 2016 RFI Report included the following conclusions relevant to the scope of work outlined herein:

1. Groundwater data indicate a previously unidentified source of VOCs located in the vicinity of MW-6. The data do not support a source of these VOCs being located at the documented SWMUs on the DVW. Additional investigation was recommended to locate this unidentified source.
2. Analytical modeling of select VOCs was performed using the Quick Domenico fate and transport model to assess the potential for contaminant migration in groundwater across the downgradient property boundary [Route 13]. Groundwater elevation data were used to construct contour maps that were then divided into six flow zones (Areas 1 through 6). VOC analytes selected for modeling represented the more mobile compounds present within individual flow areas. The Area 5 model results indicated that concentrations of trichloroethene (TCE) above RSLs could potentially extend a distance of approximately 100 feet and that concentrations of vinyl chloride above RSLs could potentially extend a distance of approximately 555 feet from the Site boundary in a south-southeast direction. The Area 6 model results indicated that concentrations of vinyl chloride above RSLs could potentially extend a distance of approximately 160 feet from the Site boundary in a south-southeast direction.
3. The results of the Baseline Human Health Risk Assessment (BHHRA), currently under review by EPA, indicate that an assessment of potential soil vapor intrusion into certain occupied structures at the Site should be conducted to verify that occupant exposures are acceptable.

These conclusions presented in the April 2016 RFI Report were referenced by USEPA, in a letter dated May 22, 2018, requesting this Work Plan.

## **2.4 PREVIOUS INVESTIGATIONS**

Previous RFI investigations are documented in the following reports submitted to the USEPA.

1. RFI Data Summary Report, Honeywell Facility, Claymont, Delaware (MWH Americas, Inc., October 2003)
2. Summary of Presentation Items, General Chemical Corporation, Delaware Valley Works Facility, Claymont Delaware (Cummings-Riter, November 7, 2003)
3. Phase II RFI Data Summary Report, Honeywell Delaware Valley Works Facility, Claymont, Delaware (MWH Americas, Inc., May 2005)
4. Soil Vapor Intrusion Investigation, Honeywell Delaware Valley Works, Claymont, Delaware (MACTEC Engineering and Consulting, Inc., December 2008)
5. AOC 16NP Investigation Report, Honeywell International Inc., Delaware Valley Works, Claymont, Delaware (MACTEC Engineering and Consulting, Inc., February 2010)
6. RCRA Facility Investigation Report, Honeywell International Inc., Delaware Valley Works, Claymont, Delaware (Amec Foster Wheeler Environment & Infrastructure, Inc., April 2016)

## **2.5 PHYSICAL SETTING**

### ***Regional Geology***

The DVW is located within the Coastal Plain Physiographic Province. The Coastal Plain consists of unconsolidated sediments from the Cretaceous, Tertiary, and Quaternary ages overlying pre-Cambrian bedrock. These unconsolidated sediments consist of gravel, sand, silt, and clay deposits. These sediments thicken eastward towards the Delaware River (Earth Sciences, 1999).

### ***Local Geology***

The DVW lies approximately 1 mile east of the Fall Line, which marks the beginning of the Piedmont Physiographic Province. Local subsurface geology is known from boring logs provided by prior investigations. The surficial unit over the majority of the DVW consists of an historic fill material used to create grades for building and to level the site. The historic fill typically ranges from 0 to 7 feet below ground surface (bgs). It is underlain by unconsolidated fluvial deposits of silty clay, which are in turn underlain by sand and gravel deposits of varying thickness. These unconsolidated units extend downward to a weathered bedrock (saprolite) grading into unweathered bedrock. Saprolite and/or bedrock are

typically encountered at approximately 16 to 19 feet bgs. At the adjacent Chemtrade property to the south of the DVW, the bedrock dips downward and is reportedly encountered at depths ranging from approximately 16 feet bgs along Philadelphia Pike to as deep as 54 feet bgs along the Delaware River. Saprolitic materials have been identified at depths of 35 feet bgs and greater near SWMU 9.

### ***Regional Hydrogeology***

The principal water-bearing zone consists of unconsolidated sand and gravel units of the Coastal Plain Sediments. Inter-bedded silts and clays may create semi-confined hydraulic conditions at depth locally. Recharge of the unconsolidated aquifer occurs mainly in the form of infiltrating precipitation and vertical leakage. The water table aquifer generally follows topography and flows from areas of higher elevation to lower elevations.

### ***Local Hydrogeology***

Characteristic of the Coastal Plain sediments of the region, the principle water-bearing zone at the DVW plant consists of an unconsolidated sand and gravel which underlies historical fill materials and discontinuous silty-clay units. Groundwater occurs in these units under water table conditions and was encountered generally between 7 and 13 feet bgs during well installations. Where present, silty-clay units may create locally semi-confined conditions. **Figure 2** is a figure depicting water table elevation contours constructed from data collected during the September 2015 event for the DVW.

Groundwater flow direction in the unconsolidated overburden at the DVW is generally towards the south toward the Delaware River discharge boundary, although there are local variations. In the northeastern portion of the DVW, shallow groundwater flows to the southeast. In the central portion of the DVW, shallow groundwater flows to the south-southwest. In the southwestern portion of the DVW, shallow groundwater flows to the south-southeast. The hydraulic gradient is estimated to be 0.004 to 0.007 feet/foot (ft/ft) in the northeastern and central portions of the DVW and 0.01 ft/ft in the southwestern portion of the DVW based on the 2015 data. Groundwater mounding is apparent in the area of monitoring wells SM19-MW2 and SM20-MW1 in the central portion of the DVW. The cause of the mounding is unknown. A relatively high water table elevation was also observed in monitoring well EWL-08 in the northwestern portion of the DVW.

Historical investigations have suggested that the Delaware River is also a discharge boundary for the uppermost bedrock, creating an upward hydraulic gradient between the bedrock and unconsolidated aquifers (Earth Sciences, 1999).

The potable water at the DVW plant is obtained from the Chester Water Authority in Chester, Pennsylvania. No production or potable wells were identified within a 0.5 mile radius database search conducted by Delaware Department of Natural Resources and Environmental Control (DNREC) and PADEP. Activities at the adjacent Sun Oil refinery within the MHIC are reported to have impacted local groundwater quality (Earth Sciences, 1999) and may have impacted groundwater in the northeast quadrant of the DVW.

### ***Surface Water***

The DVW plant is located approximately 3,000 feet upgradient of the Delaware River discharge boundary. The Delaware River, which is tidally-influenced, flows from north to south forming the south boundary SWMU 9 and the Chemtrade property. Storm water from the DVW, Philadelphia Pike, and the Chemtrade property is discharged into storm sewers that ultimately discharge to the sluiceway on the Chemtrade property. The sluiceway extends approximately 1,800 feet south through the Chemtrade property and along the western perimeter of SWMU 9 to its outfall in the Delaware River. The outfall is a National Pollutant Discharge Elimination System (NPDES) discharge point maintained and monitored by Chemtrade.

## **2.6 CONCEPTUAL SITE MODEL**

The June 16, 2015 RFI Work Plan presented a preliminary Conceptual Site Model (CSM) for the DVW to identify potentially complete current exposure pathways, and current and reasonably expected future receptors. The DVW is an operating chemical manufacturing facility with 24-hour security staff, controlled access, security fencing, and video surveillance. Photo-identification is worn by all authorized Site personnel. Consequently, while trespassing on the site is a possibility, it is unlikely that a trespasser would be able to gain access and remain on the property undetected.

The DVW plant is located within an area zoned for heavy industry and is surrounded on all sides by refineries or other heavy industrial facilities. Residential use and residential populations as receptors are not reasonably expected future exposure scenarios.

The DVW plant property, with the exception of SWMU 9, is distant from the nearest water body that might serve as a habitat. The Delaware River is located approximately 3,000 feet to the south. Storm water drainage from the DVW plant is conveyed to the Delaware River via storm sewers and a sluiceway. These features were remediated in 2011 and 2013, respectively, and an Interim Measure for remediation of sediment in the Delaware River adjacent to SWMU 9 is being designed. On the plant itself, there are no undeveloped or native vegetation areas that might serve as habitat for wildlife, although the vegetation that covers SWMU 9, in view of its remoteness from human activities, serves as habitat. Consequently ecologic exposure scenarios are not of concern on the DVW plant, but were considered on SWMU 9.

Based on discussions held with USEPA during the August 28, 2014 scoping meeting and the current and reasonably expected current and future site use, the receptor populations with the potential to be exposed to the COCs include:

- Site Workers
- Construction Workers
- Trespassers
- Ecologic Receptors (SWMU 9 only)

The SWMUs/AOCs are locations where disposal of hazardous constituents is known or believed to have historically occurred. Potential pathways for hazardous constituents to migrate away from the SWMUs/AOCs include:

- Surficial erosion of particulates due to storm water runoff and wind;
- Migration of hazardous constituents from their disposal location into subsurface soils under the forces of gravity;
- Volatilization of hazardous constituents into the air or soil vapor; and
- Leaching of hazardous constituents from the waste mass or underlying soils into groundwater with migration down gradient as part of the groundwater flow. With the exception of SWMU 9, discharge of dissolved constituents in groundwater to surface water is not a currently complete pathway on the Site due to the distance between the Site and the Delaware River.

The 2016 BHHRA, currently under review by EPA, evaluated exposure scenarios and current and reasonably expected future receptors associated with these migration pathways and concluded the following:

- Soil exposure scenarios would include Site and construction workers and adult and child trespassers exposed to surface soil (0 to 2 feet) and construction workers for soil at depths from 0 to 10 feet at DVW and 0 to 15 feet at SWMU 9 via incidental ingestion, inhalation of airborne particulates, inhalation of ambient vapors, and dermal contact. Site workers also have the potential for inhalation of groundwater vapors through indoor air, although this potential may be mitigated by intermittent occupancy and ventilation conditions in many of the Site buildings.
- Residential exposure to soil and groundwater, and exposure to groundwater as a drinking water source, were eliminated from the risk assessment due to current and foreseeable future industrial land use conditions.

### 3.0 SCOPE OF WORK

The following sections describe the specific tasks required to complete the proposed Scope of Work. The work will be conducted in accordance with the Standard Operation Procedures (SOPs) included in Appendix A of the January 2015 RFI QAPP approved by USEPA (see **Appendix A** for update pages of the QAPP).

#### 3.1 SYNOPTIC ROUND OF WATER LEVELS

Wood will conduct a synoptic round of water levels from existing monitoring wells (see **Figure 2**). The water level data will be used to develop a current groundwater contour map to aid in the inference of potential source(s) of VOCs near MW-6 and groundwater delineation at Areas 5 and 6. Water levels will be collected in accordance with SOP S-6 from a total of 41 wells listed below.

- MW-01
- MW-03
- MW-04
- MW-05
- MW-06
- MW-07
- MW-08
- MW-09
- MW-12
- MW-13
- MW-102
- MW-103
- MW-104
- MW-112
- MW-116
- MW-117
- EWL-05
- EWL-08
- SM13-MW1
- SM14-MW1
- SM14-MW2
- SM15-MW1
- SM15-MW2
- SM16-MW1
- SM16-MW2
- SM17-MW1
- SM17-MW2
- SM18-MW1



- SM19-MW1
- SM19-MW2
- SM20-MW1
- SM20-MW2
- SM20-MW3
- SM21-MW1
- SM21-MW2
- SM22-MW1
- SM22-MW2
- SM23-MW1
- SM27-MW1
- AOC16-MW1
- AOC16-MW2

### **3.2 BACKGROUND RESEARCH**

The purpose of the background research task is to evaluate the possibility of existing wells on the downgradient MHIC property to the south of the Site which may have data useful for the delineation of groundwater impacts at Areas 5 and 6. The research will include contacting MHIC to inquire about potential monitoring wells and, if necessary, a review of files available at PADEP and USEPA for the MHIC property to the south and for the Braskem property to the east, which could potentially have monitoring wells associated with their properties at locations downgradient of Areas 5 and 6. Existing data, if available, will be reviewed and evaluated to aid in the delineation.

### **3.3 SURFACE GEOPHYSICAL SURVEY**

Prior to any intrusive work, Wood will contact PA-One Call to locate public utilities. In addition, a surface geophysical survey will be conducted in all proposed sampling areas to evaluate soil boring and monitoring well locations for subsurface features (tanks, utilities, piping, etc.) and the first 5 feet of the boring will be air-knifed prior to drilling. The locations of the proposed soil borings and monitoring wells may be modified based on the results of the surface geophysical survey.

### **3.4 MW-6 VOCs SOIL BORINGS**

The objective of the MW-6 VOCs soil borings task is to attempt to locate and delineate the unidentified source of VOCs observed in monitoring well MW-6 via the collection of soil and groundwater samples. Sampling and analysis will be conducted in accordance with the methods included the USEPA-approved QAPP.

Soil borings which intersect the water table are considered wells in the State of Delaware and must be permitted. Wood will contract a Pennsylvania and Delaware-licensed well driller to conduct soil boring activities in the area of MW-6 since MW-6 is near the border of



the two States. The driller will obtain well permits for each boring on the Delaware side in accordance with DNREC requirements.

Wood will install 14 soil borings in accordance with SOP S-15 in the area of MW-6 (see **Figure 3**). The borings will be installed using direct push technology (i.e., Geoprobe®), with the first 5 feet of the subsurface cleared using an air knife. The borings will then be off-set adjacent to the cleared location so that the first 5 feet can be sampled. For borings installed in paved areas, a concrete coring machine will be used to core through the concrete prior to installing the boring. Conditions permitting, the borings will be installed to refusal or into groundwater, which is expected to be at a depth of approximately 10 feet bgs. Any non-disposable equipment that could potentially come into contact with samples will be decontaminated prior to use by using Alconox® (or similar) followed by a distilled or potable water rinse in accordance with SOP S-4.

Soil borings will be advanced continuously using direct push drilling methods to using a Geoprobe®. Materials recovered from borings were inspected by the field geologist for presence (or absence) of waste materials, staining, and other visual or olfactory indicators of impacts, and will be screened using a photo-ionization detector (PID). Key observations made by the field geologist at every boring included:

- Depth of first encounter with groundwater; and,
- Visual or other evidence of waste materials;
- The boundary between fill or waste materials and native soils.

The field geologist will select soil samples based upon visual, olfactory, and PID screening for laboratory analyses according to these criteria:

- No soil samples will be collected from below the water table for laboratory analyses.
- For the purpose of horizontal delineation, the soil samples will be selected to be representative of native material beyond the horizontal limits of any distinguishable waste materials.
- For the purpose of vertical delineation, the subsurface soil sample intervals will be selected to be representative of:
  - Native material beyond the vertical limit of waste.
  - If waste materials or gross impacts from waste materials extended below first encounter with groundwater, drilling will continue until native soils are encountered and assumed to be impacted to that depth.

Up to three samples per boring are estimated to be collected for submittal for laboratory analysis; the actual number of samples analyzed will be based on field observations.

One groundwater sample will be collected from each boring by installing a temporary PVC screen inside the boring in accordance with SOP S-15. A peristaltic or submersible pump will be used to pump groundwater from the boring for the purpose of removing fines. Once field observations indicate that the groundwater has cleared a bailer will be slowly lowered

into the PVC screen to collect the groundwater sample. The groundwater does not need to be clear of all fines prior to sampling, but enough so that the turbidity does not cause air bubbles in the sample.

Soil and groundwater samples will be submitted for laboratory analysis by a Pennsylvania-licensed laboratory for VOCs via USEPA Method 8260.

Duplicate samples will be collected at a rate of 10% (one sample per 10) and analyzed for VOCs via USEPA Method 8260. Matrix Spike/Matrix Spike Duplicate (MS/MSD) analysis will be collected at a rate of 5% (one sample per 20) and analyzed for VOCs via USEPA Method 8260. One trip blank per shipment of samples will also be collected and analyzed for VOCs via USEPA Method 8260. If non-disposable equipment is used to sample, equipment blanks will be collected at a rate of 10% (one sample per 10) by pouring laboratory-provided DI water over the decontaminated equipment and submitted for analysis for VOCs via EPA Method 8260. Chain-of-custody will accompany the field samples at all times, from the time the samples are collected until final analysis at the laboratory.

**Table 1** summarizes the general sampling and analysis plan for the proposed RFI Phase IV borings and monitoring wells in the MW-6 area. Soil borings proposed for the MW-6 area are depicted on **Figure 3**. Sample locations may be modified based on the results of the surface geophysical survey.

Decontamination fluids and pumped groundwater will be containerized for eventual offsite disposal at a licensed facility. Soil cuttings will be containerized and staged at a Honeywell designated location on the Site for eventual offsite disposal at a licensed facility. Boreholes will be backfilled with a neat grout mixture. The pavement coreholes will be backfilled with cement.

Based on the initial soil and groundwater results, additional delineation borings and sampling may be recommended.

Multiple lines of evidence will be used to demonstrate that the source area(s) has been identified and delineated. These lines of evidence will include the background concentrations, distance from source areas, concentration gradients, comparisons to screening criteria, and depth considerations.

### 3.6 MONITORING WELL INSTALLATION

Two wells will be installed downgradient of Areas 5 and 6, one downgradient of existing well MW-13 and one downgradient of existing well SM13-MW1 (see **Figure 4**). The results of the direct push sampling at the MW-6 area will be evaluated and, based on these results, permanent groundwater monitoring wells will be installed to assess the extent of groundwater impact during a second field mobilization. The results will be provided to the USEPA via an interim report, along with proposed permanent monitoring well locations at the MW-6 area for approval.

The wells will be installed in accordance with SOP S-11 and constructed of 2-inch diameter PVC with approximately 7 feet of screen below the water table and 3 feet of screen above the water table to allow for approximately 2 feet of sandpack above the top of screen and approximately 2 feet of bentonite above the sandpack. The annular space above the bentonite will be grouted with Portland cement or Portland cement /bentonite slurry to the top of the well. Each monitoring well will be completed with either a stick-up or a flush-mounted steel lid and concrete pad, depending on its location.

Cuttings produced during well construction will be containerized for eventual offsite disposal at a licensed facility.

The monitoring wells will be developed by pumping and surging to remove sediment that may have accumulated during well installation, to consolidate the filter pack around the well screen, and to enhance the hydraulic connection between the target zone and the well. Development of the monitoring well will take place no sooner than 24 hours following the grout seal placement using a submersible pump and surge block. The pump and surge block will be deconned (by drillers) prior to arrival onsite. The pump will be lowered into the well to mid-screen and the water will be pumped and containerized for disposal. Surging will be conducted slowly to reduce disruption to the filter pack and screen. The well will be considered fully developed with all of the following criteria have been met:

- Discharge water is clear to the unaided eye;
- Sediment thickness remaining in the well is less than one percent of the screen length; and
- Total volume of water removed from the well equals five times the standing water volume in the well (including the well screen and casing plus saturated annulus, assuming 30 percent porosity).

Well development water will be containerized for eventual offsite disposal at a licensed facility.

### 3.7 GROUNDWATER SAMPLING

Following completion of the soil boring and the Geoprobe® groundwater sampling, a groundwater sampling event using permanent groundwater monitoring wells will be conducted in accordance with SOP S-1 in the MW-6 VOCs area and the Area 5 and 6 to

confirm the temporary point groundwater sampling results and evaluate current groundwater quality conditions in those areas. The following wells are proposed for sampling:

- MW-6 VOCs Area
  - MW-6
  - MW-5
  - SM17-MW1
  - SM20-MW2
  - SM20-MW3
  - Newly installed wells
- Areas 5 and 6
  - SM14-MW2
  - SM13-MW1
  - MW-1
  - MW-13
  - Two newly installed wells (A5-01 and A6-01)

Prior to sampling of the wells, initial depth to groundwater and depth to product (if applicable) will be measured with an interface probe. The interface probe and pump, and any other non-disposable equipment, will be deconned prior to lowering it into the well using Alconox® (or similar) followed by a distilled or potable water rinse.

**Table 1** provides the parameter suites for laboratory analyses of groundwater. **Figure 2** depicts the locations of the wells to be sampled.

Low flow methods will be used to conduct groundwater sampling in accordance with SOP S-1. A peristaltic or submersible impeller driven (e.g., Whale or Monsoon) pump will be lowered in the well with the intake set at the midpoint of the water column and the tubing connected to the flow-through cell. Purging will be conducted at a rate of less than 500 milliliters per minute (ml/minute) with the water level monitored during purging to maintain not more than 0.3 feet of head change. During the purging process, process water quality parameters dissolved oxygen, oxidation/reduction potential (ORP), conductivity/specific conductance, temperature, pH, turbidity, and water level will be measured and recorded at least every five minutes. Purging will continue until monitoring parameters stabilized after three consecutive readings within the following limits:

- Turbidity - +/- 10% for values greater than 10 NTU; if turbidity is greater than 10 and the well does not stabilize continue purging well for up to two hours, collect sample, and document on field data record and in log book
- Dissolved Oxygen - +/- 10%
- Specific Conductance +/- 3%
- Temperature - +/- 3%
- pH - +/- 0.1 standard units

- ORP - +/- 10 mV
- Water level - <0.3 feet

After the parameters have stabilized to the above criteria, a dedicated bailer will be slowly lowered into the well until it is submerged, carefully to avoid excessive agitation and aeration. The bailer will be retrieved and water will be poured into laboratory-provided bottles. Samples will be submitted for analysis for VOCs USEPA Method 8260.

Duplicate samples will be collected at a rate of 10% (one sample per 10) and analyzed for VOCs. One trip blank per shipment of samples will also be collected and analyzed for VOCs. If non-disposable equipment is used to sample, one equipment blank will be collected at a rate of 10% (one sample per 10) by pouring laboratory-provided DI water over the decontaminated pump and submitted for analysis for VOCs. MS/MSD samples will be collected at a rate of 5% (one sample per 20). A chain-of-custody will accompany the field samples at all times, from the time the samples are collected until final analysis at the laboratory.

Based on the groundwater results, additional delineation sampling may be required.

Multiple lines of evidence will be used to demonstrate that the nature and extent of the impact to groundwater has been delineated. These lines of evidence will include the background concentrations, distance from source areas, concentration gradients, comparisons to screening criteria, and depth considerations.

### 3.8 SOIL VAPOR INTRUSION

The purpose of the soil vapor intrusion task is to assess soil vapor intrusion within occupied structures at the Site as recommended based on the results of the BHHRA included with the April 2016 RFI Report submittal.

The soil vapor intrusion assessment will be conducted in a phased approach in accordance with USEPA guidance<sup>1</sup>. The USEPA guidance uses conservative attenuation factors and screening levels that are protective of human health and emphasizes the use of multiple lines of evidence to evaluate the potential for a vapor intrusion risk and to support conclusions for further action. The USEPA recommends that the investigation work plan include the identification of and basis for indoor air screening levels, such as the USEPA's vapor intrusion screening levels (VISLs), which would dictate the sampling and analysis methods. The primary objective of risk-based screening is to identify sites or buildings unlikely to pose a health concern through the soil gas intrusion pathway. Generally, at properties where subsurface concentrations of vapor-forming chemicals, such as those in groundwater or "near source" soil gas, fall below the recommended screening levels (i.e.,

---

<sup>1</sup> OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, USEPA, Office of Solid Waste and Emergency Response, June 2015

VISLs), no further action or study is warranted<sup>1</sup>. The proposed vapor intrusion evaluation steps are as follows:

1. Screening of existing groundwater data using the USEPA VISL calculator, a generic screening level calculator to evaluate the need for soil gas sampling (<https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator>). The results of this screening step are included in this Work Plan (see **Existing Data Evaluation** below).
2. Sub-slab soil gas (SSSG) sampling, with the collection of indoor air (IA) and outdoor air (OA) samples at the same time. Angle drilling techniques will be used to collect soil gas samples from beneath the target slab, or as close to the target slab as physically possible.
3. Review of soil gas sampling results to evaluate the need to analyze the IA samples.

The following buildings are considered occupied at the Site (see **Figure 5**):

- Building 7 (Guard House). This is standard office space occupied by at least one person in three shifts of 8 hours each for 24 hours per day (hrs/day) and a second person for one shift of 8 hrs/day. The guards move in and out of the building throughout the shifts to check vehicles and perimeter security. Building is slab-on-grade construction.
- Admin Building (no building number). Standard office space and conference rooms. Slab on grade construction with no basement. Portion of building has 2nd floor with three offices. Occupied by eight persons Monday through Friday approximately 10 hrs/day.
- Building 23 Warehouse. Occupied by two persons for 10 hrs/day Monday through Friday. Building is slab-on-grade construction.
- BF<sub>3</sub> Control Room. The control room is located on the first floor of this process area, and is occupied by one to two persons that move in and out of the room during production. It is standard office space that is air conditioned. Building is slab-on-grade construction.

The Sealants Area (Building 16) is rarely used. The Garage to the north of the Admin Building and Building 17 have roll-up garage doors resulting in a lack of negative building interior pressure and multiple air exchanges per hour (ACH), which are underlying factors (advection) that mitigate potential vapor intrusion. Therefore, these structures are not considered for evaluation. There are no other occupied buildings.

### ***Existing Data Evaluation***

The VISL calculator was used as a screening method to assess indoor air concentrations based on the most recent groundwater concentrations for wells within a 100-foot radius of occupied buildings in accordance with USEPA guidance, assuming the following:

- Hazard quotient of 0.1

- Target risk of  $1 \times 10^{-6}$
- Commercial exposure
- Site-specific screening level
- Default groundwater temperature

For buildings with more than one well within 100 feet, the highest concentration for each detected VOC was used. Individual VISL calculator runs were used to evaluate each of the monitoring well samples. Only detected compounds from each location were used as input values so that the corresponding indoor air concentration, VI carcinogenic risk (CR), and VI hazard quotient (HQ) could be calculated.

To comply with concerns regarding cumulative risks and hazards, individual VOCs CR and HQ values for each sample location was then summed to get a cumulative CR and a Hazard Index (HI), respectively. The cumulative CR values was compared to USEPA's acceptable range of  $1.00\text{E-}06$  to  $1.00\text{E-}04$ . The HI was compared to USEPA's threshold value of 1, conservatively assuming that the hazards were additive and all VOCs acted on the same target organ system. The screening results are summarized below and the VISL outputs are included in **Appendix D**.

**Table 2 VISL Results**

Building	Well and Distance from Building	Cumulative Carcinogenic Risk (CR)	Cumulative Hazard Quotient (HQ)	Sub-slab Soil Gas Sampling Recommended
Building 7	MW-104 (87.7 feet)	$1.01\text{E-}04$	$4.37\text{E+}00$	Yes
Admin Building	MW-04 and MW-05 (16.9 and 74.7 feet)	$2.32\text{E-}07$	$8.31\text{E-}02$	No
Building 23 Warehouse	MW-08 (43.9 feet)	$5.63\text{E-}08$	$7.01\text{E-}05$	No
BF <sub>3</sub> Control Room	SM19-MW1 and SM19-MW2 (44.6 and 36.7 feet)	$4.40\text{E-}05$	$1.33\text{E+}01$	Yes

### ***Sample Collection***

SSSG sampling will be conducted at Building 7 and the BF<sub>3</sub> Control Room based on the results of the VISL calculations. Samples will be collected from four locations at each building, one on each side of the building, biased toward areas of the building that are the most occupied (see **Figure 5**). The sampling will be conducted during the heating season using a Geoprobe® and angled drilling techniques in accordance with SOP-15.



Prior to the sampling event, a building survey will be conducted to evaluate potential impacts to indoor air sampling (e.g., potential sample contaminants) and Honeywell occupants will be provided a summary of the sampling procedures and instructions to follow at least 48 hours prior to and during the sampling event (e.g. do not smoke, do not use cleaning products, and keep doors and windows closed). Indoor air sampling will be conducted in accordance with SOP S-17 included in Appendix A of the QAPP, including the completion of an Indoor Air Building Survey Form and a Sampling Form (see **Appendix A**).

Each SSSG location will be sampled as closely to the foundation as physically possible to maneuver the Geoprobe® rig. At each sample location hollow drill rods will be advanced approximately 8 feet into the ground using a direct push Geoprobe® rig at a 45° angle, beginning at an assumed distance of approximately 4 feet from the building wall. This will result in a sample collection depth interval of approximately 5.5 feet below the building floor slab. Upon reaching the designated sample depth, the Geoprobe® rods will be retracted approximately 4 inches and a dedicated length of quarter inch Teflon® sample collection tubing will be inserted to the bottom of the hollow drill rod. The annular opening at top of the rod around the sample collection tubing will be sealed with modeling clay or similar material in accordance with SOP-17.

All samples will be collected using individually certified, 6-liter Summa™ canisters with initial vacuum readings of no less than -26 inches of Mercury ("Hg). SSSG sample flow rates will be set to a maximum of 12.5 milliliters per minute (ml/min) for primary samples, corresponding to a sample collection time of 8 hours. Duplicate samples will be set to a maximum of 25 ml/min, corresponding to a sample collection time of 8 hours. Sample flow rates of the IA and OA samples will be set to a maximum of 12.5 ml/min, corresponding to a sample collection time of 8 hours.

Helium will be used as a tracer gas to verify there are no leaks in sampling setup. Helium will be applied into a shroud until the atmosphere within the shroud is between 15-20% helium, as measured by a helium detector. The system will be purged using a vacuum pump and a helium detector will be used to estimate the presence of helium in the purge line. If the helium concentration within the tubing is less than 10% of the concentration within the shroud atmosphere, the seal will be considered leak-tight. If a leak is detected, the system will need to be reset and the helium leak check will need to be performed again.

Following sample collection, the Summa™ canisters will be submitted for laboratory analysis for VOCs via method TO-15. IA samples will be held, pending the results of the evaluation of data from the SSSG sampling (see **Data Evaluation** below). For those VOCs exceeding soil vapor screening criteria, IA will be analyzed for those specific VOCs only.

### ***Data Evaluation***

Similar to the existing data evaluation task, the VISL calculator will be used to assess indoor air concentrations based on the SSSG results, assuming the following:



- Hazard quotient of 0.1
- Target risk of  $1 \times 10^{-6}$
- Commercial exposure
- Site-specific screening level
- Default groundwater temperature

Individual VISL calculator runs will be used to evaluate each of the soil gas samples. Only detected compounds from each location will be used as input values so that the corresponding indoor air concentration, VI CR, and VI HQ can be calculated.

Individual compound CR and HQ values for each sample location will then be summed to get a cumulative CR and a HI, respectively. The cumulative CR values will be compared to USEPA's acceptable range of  $1.00\text{E-}06$  to  $1.00\text{E-}04$ . The HI will be compared to USEPA's threshold value of 1, conservatively assuming that the hazards were additive and all VOCs acted on the same target organ system. The IA samples will be analyzed if necessary based on the results of this evaluation.

## 4.0 REFERENCED DOCUMENTS

The following documents have been updated to address the Scope of Work included in this Work Plan. Revised pages are included in the referenced appendices.

- QAPP (included in **Appendix A**);
- SAMP (included in **Appendix B**); and
- HASP (included in **Appendix C**).

No revisions to the CRP or DMP were required.

## 5.0 REPORTING

An interim report will be submitted to the USEPA summarizing the results of the direct push sampling at the MW-6 area and at Areas 5 and 6, along with proposed permanent monitoring well locations and any other recommended investigation tasks for USEPA approval.

Upon completion of the RFI, a Draft RFI Report will be prepared for submittal to USEPA. The RFI Report will include, at a minimum, the following:

- **Introduction.** The introduction will discuss site location, site history, regulatory history, and report organization.
- **Investigation Methods.** A summary of the investigation methods and deviations from the Work Plan, if any, will be provided.
- **Local/Regional Geology and Hydrogeology.** This section will include a description of the geology and hydrogeology, including groundwater flow direction.
- **Data and Results.** A summary of the results will be provided, including tables and figures. All soil and groundwater analytical data will be subjected to data validation in accordance with the QAPP submitted to USEPA in April 2014 and subsequent updates. Data will be compared to the current USEPA RSLs and MCLs; results that meet the Achievable Laboratory Limits presented in the QAPP will be considered non-detect. Figures will include a site map showing sample locations, laboratory analytical results, isocontours, and a groundwater contour map. Boring logs, monitoring well construction logs, and laboratory analytical reports will be provided as appendices.
- **Fate and Transport.** The Quick Domenico models presented in the 2016 RFI Report will be reviewed and updated (if necessary) based on the results of the proposed Scope of Work to evaluate the extent of the groundwater impact downgradient of Areas 5 and 6.
- **Conclusions and Recommendations.** The results of the investigation will be summarized with regard to the objectives of the proposed scope of work (i.e., location and delineation of the previously unidentified source of VOCs in the vicinity of well MW-6, delineation of the groundwater impact downgradient of Areas 5 and 6, and assessment of soil vapor intrusion within occupied structures). Recommendations for next steps, and additional investigations if necessary, will be provided.

## 6.0 PROJECT MANAGEMENT PLAN

The following sections describe the project team, how it is organized, and the responsibilities of each team member. Additionally, **Section 6.2** describes the schedule for completing the work described herein.

### 6.1 PROJECT ORGANIZATION AND RESPONSIBILITIES

**Figure 6** is an organization chart that presents the key individual assignments that have been selected for this project. A summary of the responsibilities included with each assignment in the organization chart is provided below:

- **Project Manager:** The Project Manager will be fully responsible and accountable for contractual, technical, and scheduling activities, and will serve as the focal point and main channel of communication between Honeywell and the Wood team. Using the Field Team Leader, as appropriate, the Project Manager will monitor schedule and cost, and coordinate reporting. The Project Manager will also ensure that necessary resources are made available (including personnel, materials, and equipment), the project schedule is maintained, and potential problems or conflicts are identified and resolved in a timely manner. The Project Manager will be responsible for technical oversight of the project, and overall project execution.
- **Technical Advisors:** The Technical Advisors will provide technical assistance in their respective areas of expertise for specific project components. The Technical Advisors will also review and ensure the technical quality of project deliverables.
- **Project Safety Officer (PSO):** The PSO will provide the overall direction regarding matters of environmental protection, fire protection, occupational safety and health, industrial hygiene, personal protection from hazardous chemical exposure and permitting for this project. The PSO has the organizational freedom and authority to require changes to work practices, identify problems and proposed solutions, and if necessary, stop work activities that could pose a threat to personnel or the environment. The PSO will coordinate activities with the Project Manager, as appropriate.
- **Field Team Leader:** The Field Team Leader reports to the Project Manager and is responsible for project set-up of field support services. The Field Team Leader will provide oversight of field investigation tasks and investigation derived waste (IDW) management.

### 6.2 PROJECT SCHEDULE

A schedule to implement this Work Plan is shown in **Figure 7** and discussed below. This schedule is subject to change based on contractor availability, location access (e.g.,

underground utilities identified by the surface geophysical survey), and actual field conditions.

1. Within four weeks of receiving Work Plan approval from the USEPA:
  - Mobilize to the Site.
  - Conduct a round of synoptic water levels from existing wells.
  - Conduct background research for potential wells downgradient of Areas 5 and 6.
  - Contract driller and laboratory.
  - Submit drilling permit applications and receive permits (receipt assumed to be within one week of submittal).
  - Submit request to access offsite properties.
  - Install soil borings in the MW-6 VOCs area.
  - Conduct SSSG sampling.
2. Within 12 weeks of sampling at the MW-6 VOCs area and downgradient of Areas 5 and 6:
  - Receive, review, and validate soil and groundwater sample laboratory results.
  - Select permanent well locations based on laboratory results.
  - Submit interim report to USEPA with proposed permanent well locations for USEPA approval.
  - Submit drilling permit applications and receive permits (receipt assumed to be within one week of submittal)
  - Mobilize to the Site.
  - Install and develop groundwater monitoring wells.
3. Within 12 weeks of well installation:
  - Conduct groundwater sampling from select wells in the MW-6 VOCs area and Areas 5 and 6.
  - Receive, review, and validate groundwater sample results.
4. Within 12 weeks of receiving final laboratory analytical data:
  - Receive, review, and validate sample results.
  - Prepare Draft RFI Report and submit to USEPA.

In summary, we expect to complete the proposed Scope of Work and submit the RFI Report to the USEPA within approximately 10 months of receiving USEPA approval of the Work Plan.

## 7.0 REFERENCES

- CH2M Hill, 1990. *Data Collection for the Sulfuric Acid Spill Area*, Delaware Valley Works, General Chemical Corporation.
- Roy F. Weston, Inc., 1994. *Storm Water Plan*, AlliedSignal, Inc. Claymont DE.
- Earth Sciences Consultants, Inc. 1999. *RFP Work Plan RCRA Facility Lead Corrective Action Program*, Marcus Hook Facility, Claymont, DE.
- Earth Sciences Consultants, Inc., 1999. *Proposed RCRA Facility Investigation Scope of Work*, Delaware Valley Works, General Chemical Corporation.
- Cummings Riter, 2003. *Phase I Data Summary Report*.
- MWH Americas, Inc., 2003. *RFI Data Summary Report*, Honeywell Facility, Claymont, Delaware.
- MACTEC Engineering & Consulting, Inc., May 2005. *Phase II Data Summary Report, Claymont, Delaware*. (Revised and resubmitted Feb. 8, 2007)
- MACTEC Engineering & Consulting, Inc., 2008. *Soil Vapor Intrusion Investigation*, Honeywell Delaware Valley Works, Claymont, Delaware.
- MACTEC Engineering & Consulting, Inc., 2010. *AOC 16NP Investigation Report, Honeywell International Inc.*, Delaware Valley Works, Claymont, Delaware.
- Cummings-Riter Consultants, Inc., Sept 27, 2010. *Soil Sediment and Groundwater Data, General Chemical Corp., Honeywell International Inc., Claymont, Delaware*.
- AMEC Environment and Infrastructure, Inc., March 31, 2014. *Corrective Action Framework Technical Memorandum, Delaware Valley Works RCRA, Claymont DE*.
- AMEC Environment and Infrastructure, Inc., April 2014. *Quality Assurance Project Plan, RCRA Facility Investigation, Honeywell Delaware Valley Works, Claymont, Delaware*.
- Amec Foster Wheeler Environment & Infrastructure, Inc., June 2015. *RFI Work Plan, Rev. 4, Honeywell International Inc., Delaware Valley Works, Claymont, Delaware*.
- U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, June 2015. *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*.
- Amec Foster Wheeler Environment & Infrastructure, Inc., April 2016. *RCRA Facility Investigation Report, Honeywell International Inc., Delaware Valley Works, Claymont, Delaware*.

## TABLES

**Table 1. Summary of Samples and Chemical Analyses**

**RFI Phase IV Work Plan**

**Honeywell Delaware Valley Works**

**Claymont, Delaware**

		<b>SOIL*</b>	<b>GROUNDWATER<sup>1</sup></b>	<b>GROUNDWATER<sup>2</sup></b>	<b>AIR</b>
		<b>TCL-VOCs</b>	<b>TCL-VOCs</b>	<b>TCL-VOCs</b>	<b>TO-15</b>
<b>MW-6</b>	Samples	42	14	9	--
	Field Duplicates	5	2	1	--
	MS/MSD	3	1	1	--
	Equipment Blank	5	2	1	--
<b>Areas 5 and 6</b>	Samples	--	--	2	--
	Field Duplicates	--	--	1	--
	MS/MSD	--	--	1	--
	Equipment Blank	--	--	1	--
<b>Soil Gas</b>	Samples	--	--	--	8
	Field Duplicates	--	--	--	1
<b>Indoor Air</b>	Samples	--	--	--	TBD
	Field Duplicates	--	--	--	TBD
<b>Outdoor Air</b>	Samples	--	--	--	2
	Field Duplicates	--	--	--	1

\* Up to three soil samples per boring is estimated; actual number will be based on field observations.

1 – Grab groundwater samples from borings.

2 – Groundwater samples from permanent wells; additional samples to be collected from newly installed wells (actual number TBD).

TCL-VOCs - Target Compound List Volatile Organic Compounds.

TO-15 – USEPA Compendium Method TO-15.

USEPA – U.S. Environmental Protection Agency.

-- No sample collected.

MS/MSD - Matrix Spike/Matrix Spike Duplicate Analysis.

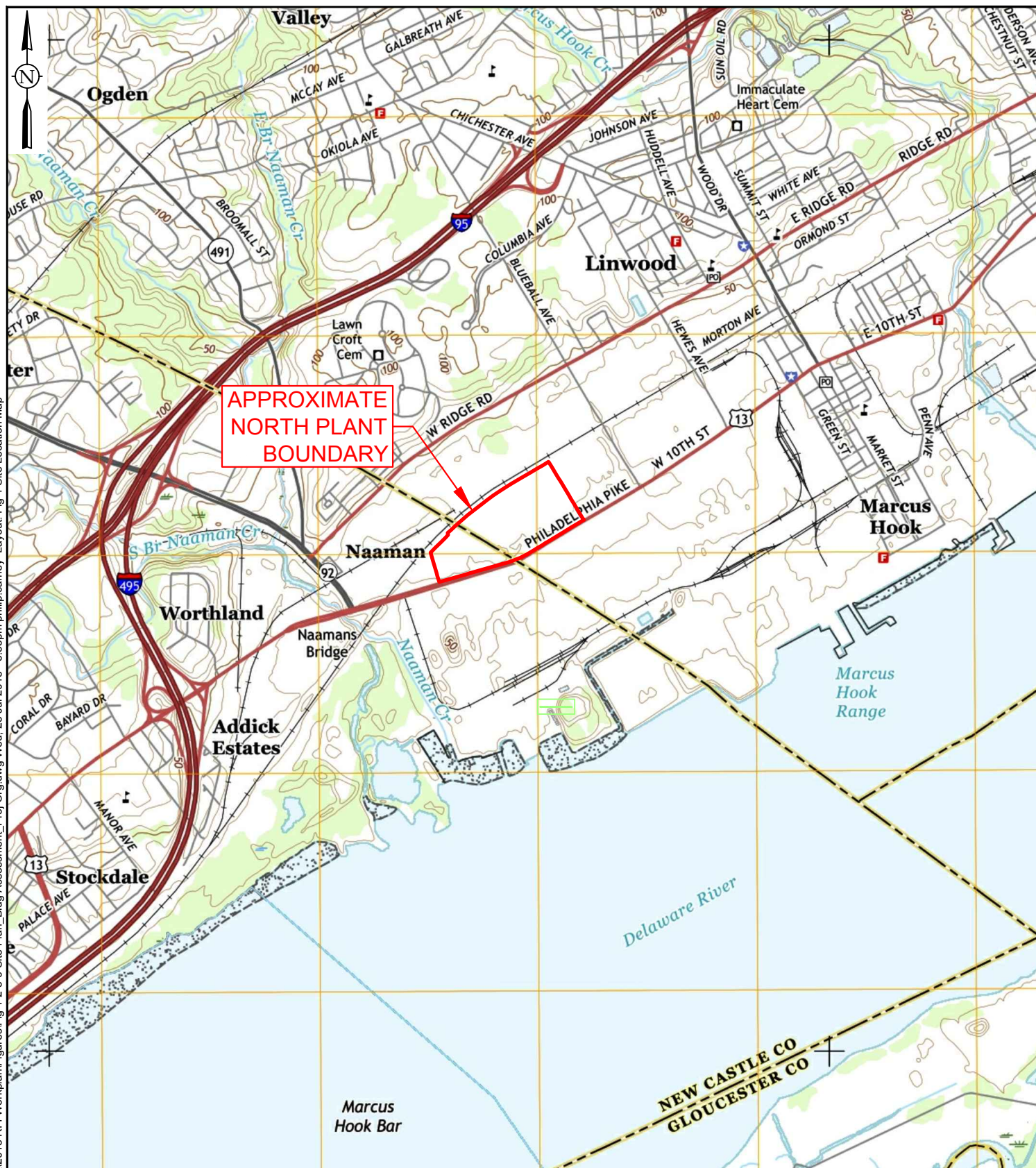
Field duplicates and Equipment Blanks will be collected at 10% frequency.

MS/MSDs will be collected at 5% frequency.

TBD – To be determined based on the results of the soil gas sampling.



## FIGURES



#### LEGEND

APPROXIMATE NORTH PLANT BOUNDARY

#### SOURCE

USGS QUAD "MARCUS HOOK, PA-DE-NJ", 2016.

0 1000' 2000'  
SCALE: 1" = 2,000'



SITE VICINITY

**Honeywell**

DELAWARE VALLEY WORKS  
CLAYMONT, DELAWARE

**wood.**

751 Arbor Way, Suite 180  
Blue Bell, PA 19422

Tel. 610-828-8100  
www.woodplc.com

#### FIGURE 1 SITE LOCATION MAP

HONEYWELL - DELAWARE VALLEY WORKS  
CLAYMONT, DE

PROJECT NO.:  
7772180021

PREPARED BY:  
PJC

CHECKED BY:  
JPM

REVISION NO.:  
0

FIGURE NO.:

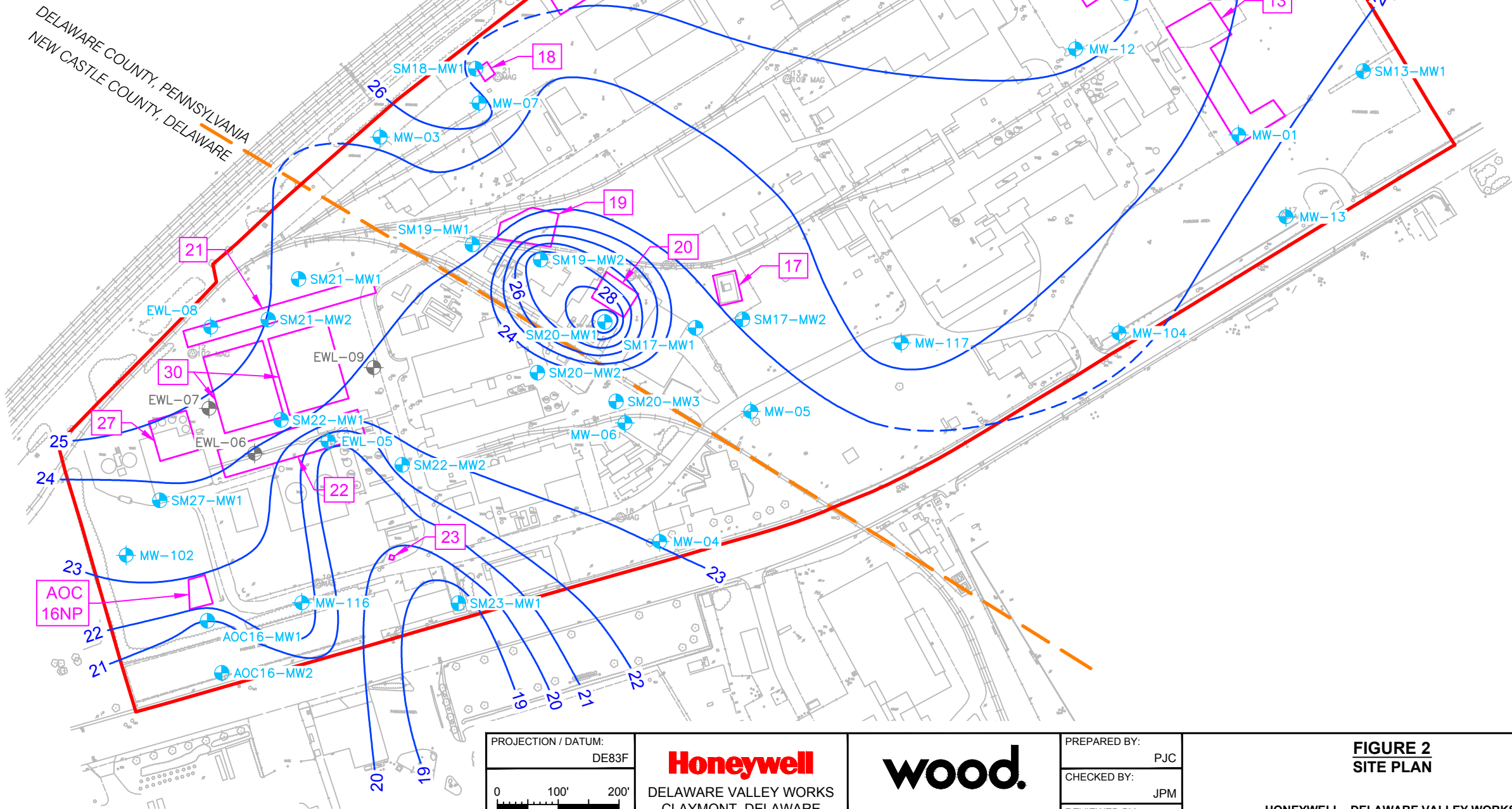
**1**



P:\Honeywell - Claymont, DE\North Plant\2018 RFI Workplan\Figures\Fig 1-2-5-6 Site Plan\_Bldg Assessment\_Proj Org.dwg Wed, 25 Jul 2018 - 5:36pm philip.camey Layout: Fig 2 Site Plan

LEGEND

- BOUNDARY BETWEEN COMMONWEALTH OF PENNSYLVANIA AND STATE OF DELAWARE
- APPROXIMATE NORTH PLANT BOUNDARY
- EXISTING MONITORING WELL LOCATION
- WELL DESTROYED OR COVERED
- APPROXIMATE SWMU BOUNDARY
- GROUNDWATER CONTOUR ELEVATION (DASHED WHERE INFERRED)



PROJECTION / DATUM:  
DE83F

0 100' 200'

SCALE: 1" = 200'

**Honeywell**

DELAWARE VALLEY WORKS  
CLAYMONT, DELAWARE

**wood.**

751 Arbor Way, Suite 180  
Blue Bell, PA 19422

Tel. 610-828-8100  
www.woodplc.com

PREPARED BY:  
PJC

CHECKED BY:  
JPM

REVIEWED BY:  
JPM

**FIGURE 2  
SITE PLAN**

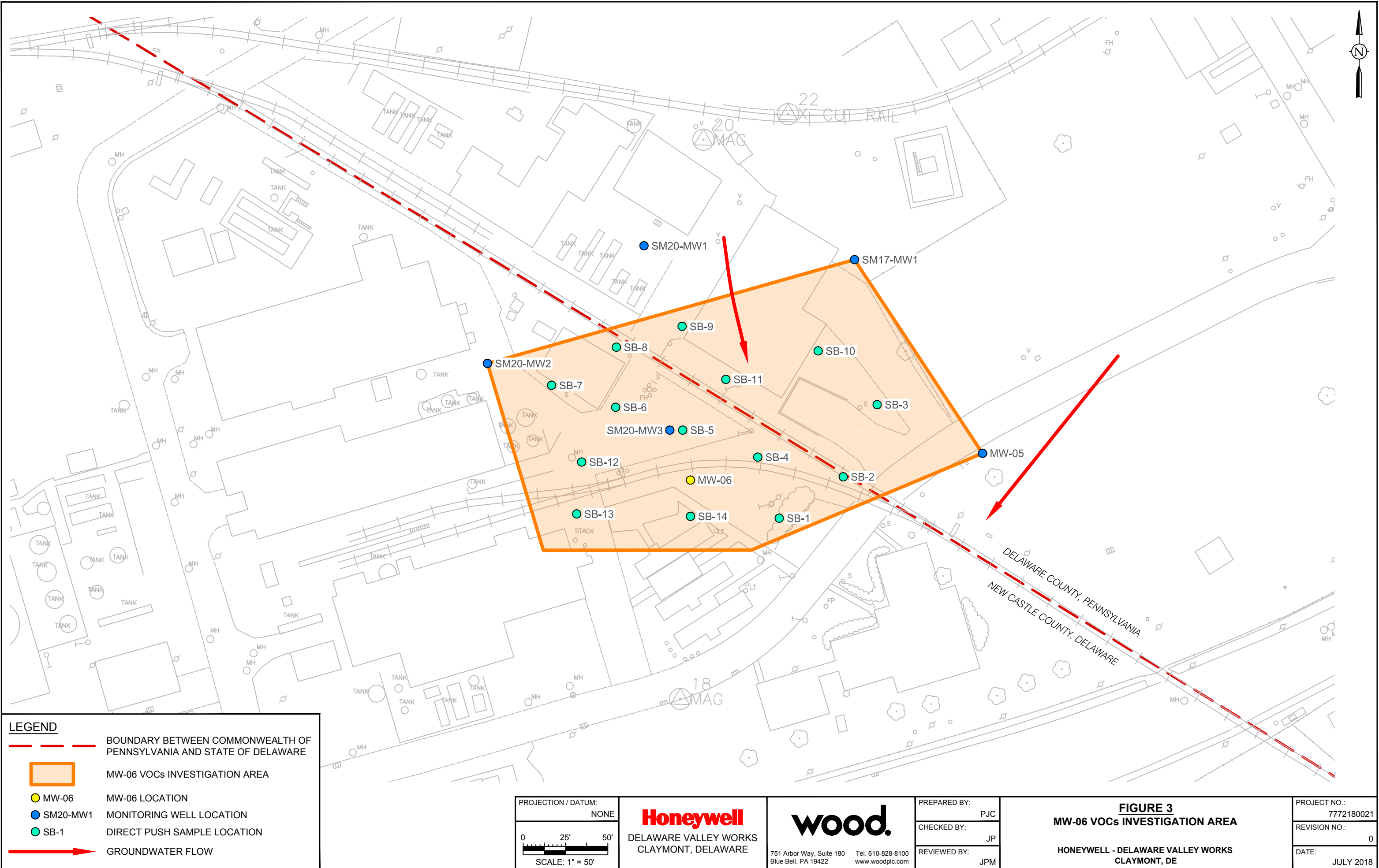
HONEYWELL - DELAWARE VALLEY WORKS  
CLAYMONT, DE

PROJECT NO.:  
7772180021

REVISION NO.:  
0

DATE:  
JULY 2018

P:\Honeywell - Claymont, DE\North Plant\2018 RFI Workplan\Figures\Fig 3-4 MW06\_Areas 5-6 Investigation Area.dwg Wed, 25 Jul 2018 - 5:39pm philip.camey Layout: Fig 3 MW-06 VOCs Investigation Area





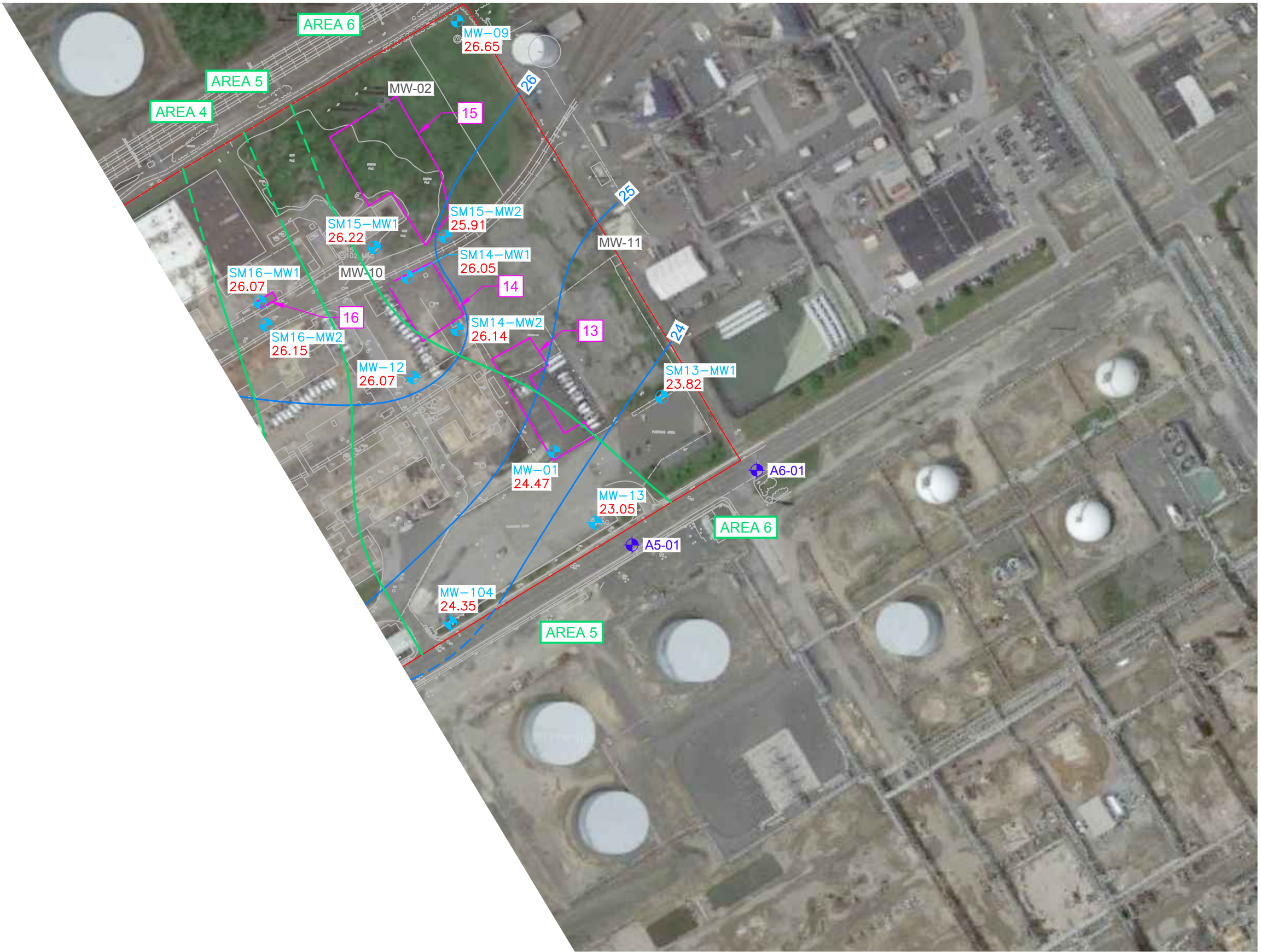
P:\Honeywell - Claymont - DE\North Plant\2018 RFI Workplan\Figures\Fig 3-4 MW06\_Areas 5-6 Investigation Area.dwg Wed, 25 Jul 2018 - 5:39pm philip.camey Layout: Fig 4 Areas 5-6 Investigation Area

LEGEND

- BOUNDARY BETWEEN COMMONWEALTH OF PENNSYLVANIA AND STATE OF DELAWARE
- APPROXIMATE NORTH PLANT BOUNDARY
- EXISTING MONITORING WELL LOCATION
- WELL DESTROYED OR COVERED
- PROPOSED MONITORING WELL LOCATION
- GROUNDWATER CONTOUR ELEVATION (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION (FT AMSL)
- APPROXIMATE SWMU BOUNDARY
- DIRECTION OF GROUNDWATER FLOW

SOURCE

GOOGLE MAPS AERIAL, 2018.



PROJECTION / DATUM:  
DE83F

0 100' 200'

SCALE: 1" = 200'

**Honeywell**

DELAWARE VALLEY WORKS  
CLAYMONT, DELAWARE

**wood.**

751 Arbor Way, Suite 180  
Blue Bell, PA 19422

Tel. 610-828-8100  
www.woodplc.com

PREPARED BY:  
PJC

CHECKED BY:  
JP

REVIEWED BY:  
JPM

**FIGURE 4**  
**AREAS 5 AND 6**  
**INVESTIGATION AREA**

HONEYWELL - DELAWARE VALLEY WORKS  
CLAYMONT, DE

PROJECT NO.:  
7772180021

REVISION NO.:  
0

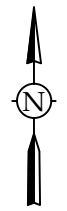
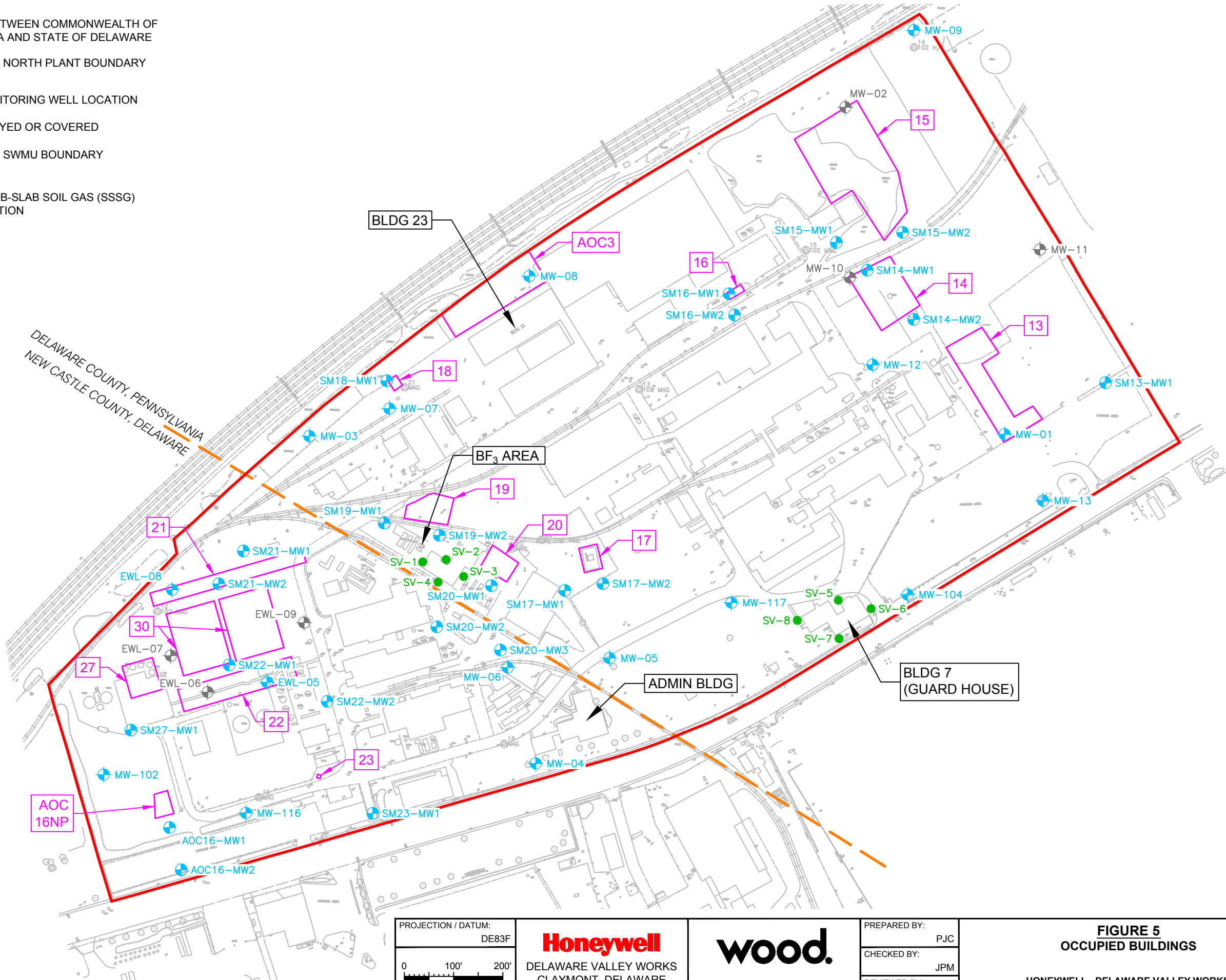
DATE:  
JULY 2018



P:\Honeywell - Claymont - DE\North Plant\2018 RFI Workplan\Figures\Fig 1-2-5-6 Site Plan\_Bldg Assessment\_Proj Org.dwg Wed, 25 Jul 2018 - 5:37pm philip.camey Layout: Fig 5 Occupied Bldgs

LEGEND

- BOUNDARY BETWEEN COMMONWEALTH OF PENNSYLVANIA AND STATE OF DELAWARE
- APPROXIMATE NORTH PLANT BOUNDARY
- EXISTING MONITORING WELL LOCATION
- WELL DESTROYED OR COVERED
- APPROXIMATE SWMU BOUNDARY
- PROPOSED SUB-SLAB SOIL GAS (SSSG) SAMPLE LOCATION



PROJECTION / DATUM:  
DE83F

0 100' 200'

SCALE: 1" = 200'

**Honeywell**

DELAWARE VALLEY WORKS  
CLAYMONT, DELAWARE

**wood.**

751 Arbor Way, Suite 180  
Blue Bell, PA 19422

Tel. 610-828-8100  
www.woodplc.com

PREPARED BY:  
PJC

CHECKED BY:  
JPM

REVIEWED BY:  
JPM

**FIGURE 5  
OCCUPIED BUILDINGS**

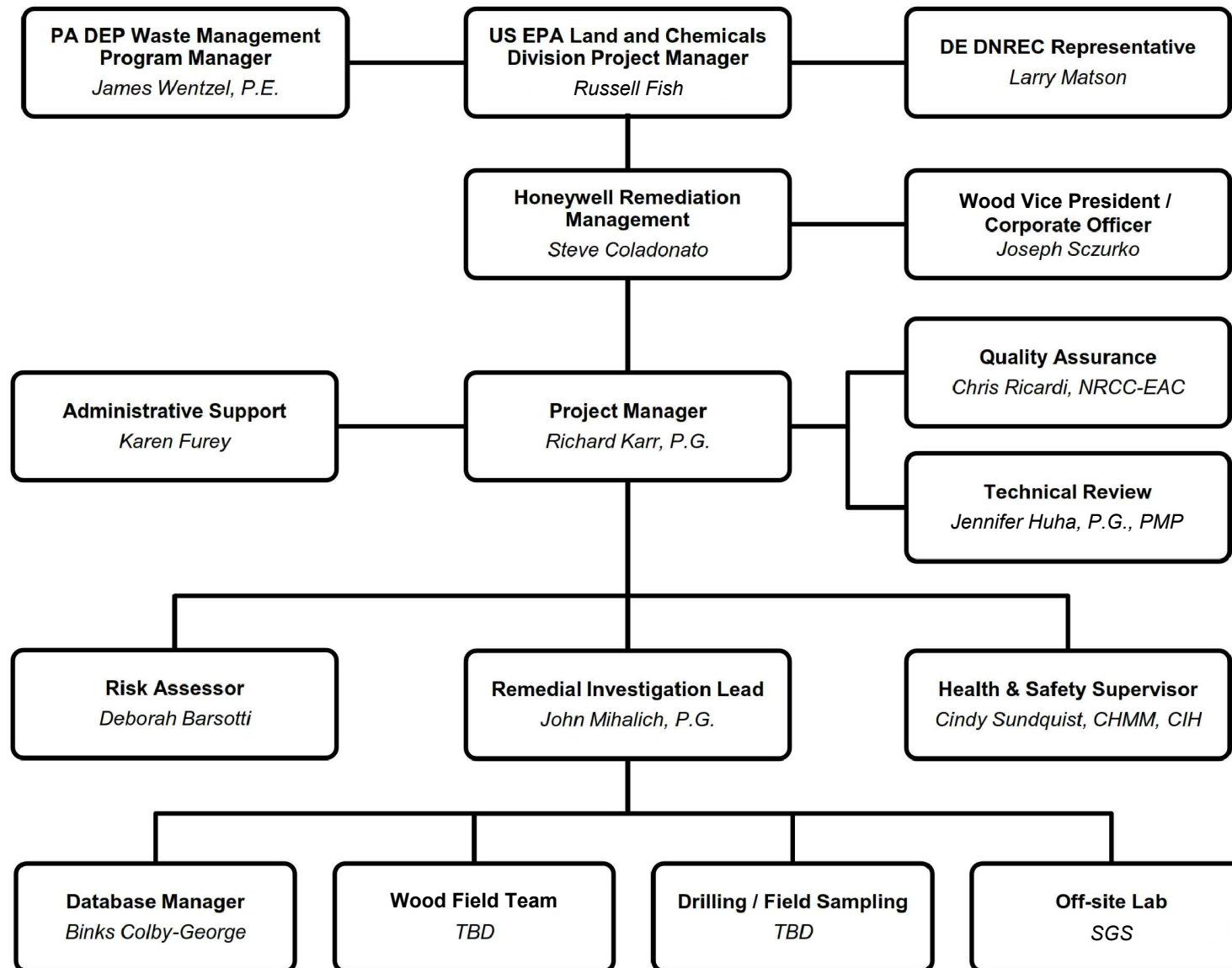
HONEYWELL - DELAWARE VALLEY WORKS  
CLAYMONT, DE

PROJECT NO.:  
7772180021

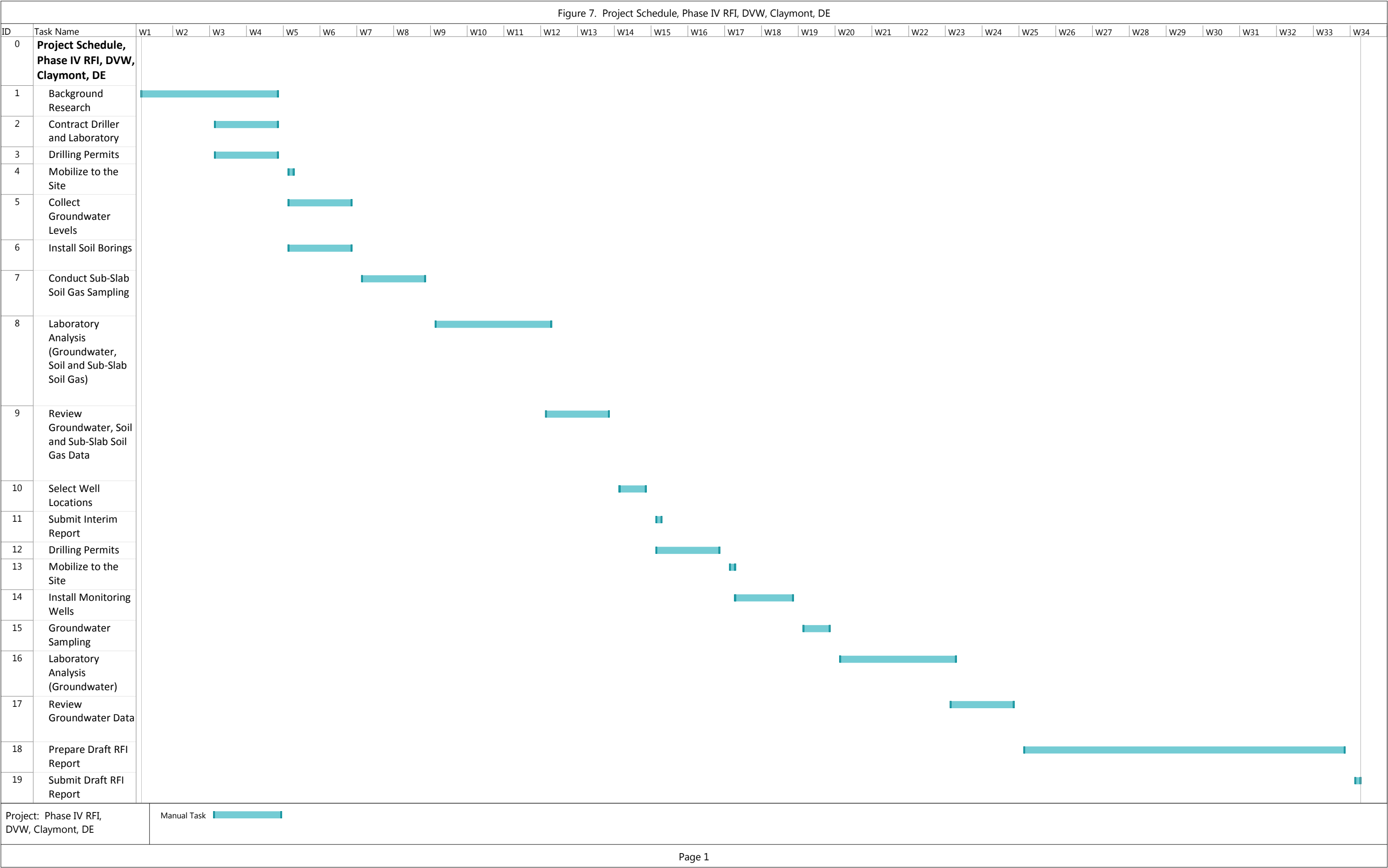
REVISION NO.:  
0

DATE:  
JULY 2018

# Project Organization Chart



PROJECTION / DATUM: NONE	 <b>DELAWARE VALLEY WORKS</b> CLAYMONT, DELAWARE	 751 Arbor Way, Suite 180 Blue Bell, PA 19422 Tel. 610-828-8100 www.woodplc.com	PREPARED BY: PJC	<b>FIGURE 6</b> <b>PROJECT ORGANIZATION CHART</b>  HONEYWELL - DELAWARE VALLEY WORKS CLAYMONT, DE	PROJECT NO.: 7772180021
			CHECKED BY: JPM		REVISION NO.: 0
NO SCALE			REVIEWED BY: JPM		DATE: JULY 2018





**APPENDIX A:**

**QAPP Update Pages**



# QUALITY ASSURANCE PROJECT PLAN RCRA FACILITY INVESTIGATION



## HONEYWELL DELAWARE VALLEY WORKS CLAYMONT, DELAWARE



*Prepared for:*

**Honeywell**

101 Columbia Road  
Morristown, NJ 07962

*Prepared by:*

**wood.**

Wood Environment & Infrastructure Solutions, Inc.  
751 Arbor Way, Suite 180  
Blue Bell, PA 19422

UPDATED JULY 2018

**TABLES**

Table 11-1	Summary of Samples and Chemical Analyses (See Worksheet 11)
Table 11-1a	Summary of Samples and Chemical Analyses (See Worksheet 11)
Table 12-1	Analytical Methods (see Worksheet #12)
Table 12-2	Project Quality Control Limits (see Worksheet #12)
Table 14-1	Summary of Sample ID Codes (see Worksheet #14)

**APPENDICES**

Appendix A	Field Sampling Standard Operating Procedures
Appendix B	Field Data Records
Appendix C	Laboratory Standard Operating Procedures

## 2.0 TITLE AND APPROVAL PAGE

**Site Name/Project Name:** Honeywell Delaware Valley Works (DVW)

**Site Location:** Claymont, Delaware

**Document Title:** Quality Assurance Project Plan, Honeywell Delaware Valley Works, Claymont, Delaware

**Lead Organization:** United States Environmental Protection Agency, RCRA Operations 3WC23

**Preparer's Name and Organizational Affiliation:** Christian Ricardi and John Mihalich, Wood Environment & Infrastructure Solutions, Inc. (Wood)

**Preparer's Address, Telephone Number, and E-mail Address:** 751 Arbor Way, Suite 180, Blue Bell, Pennsylvania 19422, Tel (610) 828-8100, [john.mihalich@woodplc.com](mailto:john.mihalich@woodplc.com)

**Preparation Date (Day/Month/Year):** April 30, 2014, Revised January 19, 2015, Revised July 2, 2018.

Investigative Organization's Project Manager/Date: \_\_\_\_\_  
Signature

Printed Name/Organization: Richard Karr/Wood

Investigative Organization's Project QA Officer/Date \_\_\_\_\_  
Signature

Printed Name/Organization: Jennifer Huha, Wood

Approval Signatures/Date: \_\_\_\_\_  
Signature

Printed Name/Title: Russell Fish/Project Manager

Approval Authority: United States Environmental Protection Agency (USEPA)

Other Approval Signatures/Date: \_\_\_\_\_  
Signature

Printed Name/Title: Larry Matson/ Delaware Department of Natural Resources and Environmental Control (DNREC) Representative

Approval Authority: DNREC

Other Approval Signatures/Date: \_\_\_\_\_  
Signature

Printed Name/Title: James Wentzel/ Pennsylvania Department of Environmental Protection (PADEP) Representative

Approval Authority: PADEP

Document Control Numbering System: Revision 2, July 2, 2018

**QAPP WORKSHEET #3 DISTRIBUTION LIST**

UFP-QAPP Manual Section 2.3.1)

List those entities to whom copies of the approved QAPP, subsequent QAPP revisions, addenda, and amendments will be sent.

☐ Worksheet Not Applicable (State Reason)**Worksheet # 3 Distribution List**

<b>QAPP Recipients</b>	<b>Title</b>	<b>Organization</b>	<b>Telephone Number</b>	<b>Fax Number</b>	<b>E-mail Address</b>	<b>Document Control Number</b>
Russel Fish	Project Manager	USEPA	215.814.3226		Fish.russel@epa.gov	
Steve Coladonato	Project Manager	Honeywell	302.791.6738		steven.coladonato@honeywell.com	
Larry Matson	DNREC Representative	Delaware Department of Natural Resources and Environmental Control	302.739.9403		lawrence.matson@state.de.us	
James Wentzel	PADEP Representative	Pennsylvania Department of Environmental Protection	484.250.5960	484.250.5914	jwentzel@state.pa.us	
Richard Karr	Wood Project Manager	Wood	610.828.8100	610.828.6700	richard.karr@woodplc.com	
John Mihalich	Remedial Investigation (RI) Lead	Wood	610.828.8100	610.828.6700	john.mihalich@woodplc.com	
Jennifer Huha	Wood Project QA Officer	Wood	610.828.8100	610.828.6700	Jennifer.huha@woodplc.com	

**QAPP WORKSHEET #4 PROJECT PERSONNEL SIGN-OFF SHEET**

(UFP-QAPP Manual Section 2.3.2)

Have copies of this form signed by key project personnel from each organization to indicate that they have read the applicable sections of the QAPP and will perform the tasks as described. Ask each organization to forward signed sheets to the central project file.

☐ Worksheet Not Applicable (State Reason)

**Worksheet # 4 Project Personnel Sign-Off Sheet**

**Organization:** Wood

<b>Project Personnel</b>	<b>Title</b>	<b>Telephone Number</b>	<b>Signature</b>	<b>Date QAPP Read</b>
Richard Karr	Project Manager	610.828.8100		
John Mihalich	RI Lead	610.828.8100		
Jennifer Huha	Project QA Officer	610.828.8100		
Deborah Barsotti	Risk Assessment Lead	609.631.2902		
TBD	Project Engineer			
Binks Colby George	Project Database Manager	207-775-5401		
Christian Ricardi	Project Chemist	207-775-5401		

## QAPP WORKSHEET #4

(UFP-QAPP Manual Section 2.3.2)

Have copies of this form signed by key project personnel from each organization to indicate that they have read the applicable sections of the QAPP and will perform the tasks as described. Ask each organization to forward signed sheets to the central project file.

☐ Worksheet Not Applicable (State Reason)

**Worksheet # 4 Project Personnel Sign-Off Sheet**

**Organization:** SGS Laboratories, Dayton, New Jersey

Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
Charles Hartke	Lab QA Director	732.329.0200		
Rocus Peters	Lab Project Manager	732.329.0200		

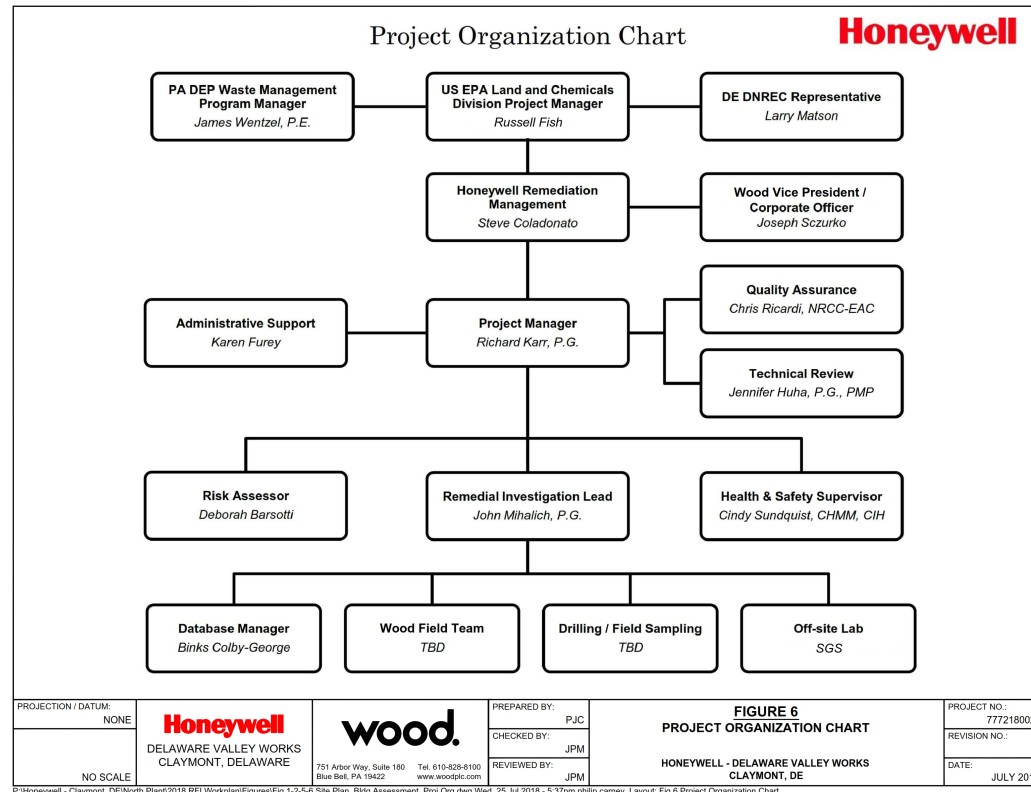
## QAPP WORKSHEET #5 PROJECT ORGANIZATIONAL CHART

(UFP-QAPP Manual Section 2.4.1)

Identify reporting relationships between all organizations involved in the project, including the lead organization and all contractor and subcontractor organizations. Identify the organizations providing field sampling, on-site and off-site analysis, and data review services, including the names and telephone numbers of all project managers, project team members, and/or project contacts for each organization.

☐ Worksheet Not Applicable (State Reason)

## Worksheet # 5 Project Organizational Chart





## QAPP WORKSHEET #6 COMMUNICATION PATHWAYS

(UFP-QAPP Manual Section 2.4.2)

Describe the communication pathways and modes of communication that will be used during the project, after the QAPP has been approved. Describe the procedures for soliciting and/or obtaining approval between project personnel, between different contractors, and between samplers and laboratory staff. Describe the procedure that will be followed when any project activity originally documented in an approved QAPP requires real-time modifications to achieve project goals or a QAPP amendment is required. Describe the procedures for stopping work and identify who is responsible.

☐ Worksheet Not Applicable (State Reason)

## Worksheet #6 Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure_(Timing, Pathways, etc.)
Point of contact for DNREC	DNREC Representative	Larry Matson	302.739.9403	Will coordinate project tasks/reports review/decision and approval for DNREC.
Point of contact for PADEP	PADEP Representative	James Wentzel	484.250.5960	Will coordinate project tasks/reports review/decision and approval for PADEP.
Point of contact with Honeywell Project Manager	USEPA Project Site Manager	Russel Fish	215.814.3226	Will provide RI planning documents to the Honeywell Project Manager. Communicates project investigation info to Honeywell.
Manage all Project Phases	Wood Project Manager	Richard Karr	610.828.8100	Will serve as the Wood liaison to all agencies for the RI.
Coordinate Field Program	Wood RI Lead	John Mihalich	610.828.8100	Coordinate field investigation activities. To be notified of field related questions/problems by phone, e-mail, or fax.

## Worksheet #6 Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure_(Timing, Pathways, etc.)
Coordinate Field Activities and requests, QAPP changes in the field	Field Operations Leader (FOL)	TBD	TBD	To notify Project Manager by phone and e-mail of any QAPP changes made in the field and the reasons within 2 business days.
Advises Wood RI Lead and Project Manager on lab issues and provides technical oversight to Lab	Wood Project Chemist	Christian Ricardi	207-775-5401	Lab technical coordination and oversight. Supervision of data validation.
Reporting Lab data Quality Issues, SGS Laboratories	Laboratory Quality Manager	Charles Hartke	732.329.0200	All QA/QC issues involving project field samples will be reported by the Laboratory QA Director to Lab Project Manager who will contact the Wood Project Manager (PM) and project chemist.
Field and Analytical Corrective Actions	Wood Project QA Officer	Jennifer Huha	610.828.8100	The need for corrective action for field and analytical issues will be determined by the project QA officer in conjunction with the Wood Project Manager, the RI Lead, FOL, project chemist and the Laboratory QA Director, as appropriate.
Release of Analytical Data	Wood Project Chemist	Chris Ricardi	207.775.5401	No final analytical data can be released until validation is completed and project chemist has approved the release.

## Worksheet #6 Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure_(Timing, Pathways, etc.)
QAPP Amendments	Wood Project QA Officer	Jennifer Huha	610.828.8100	Any major changes to the QAPP must be approved by the Wood Project Manager, and the Project QA Manager before the changes can be implemented.

## QAPP WORKSHEET #7 PERSONNEL RESPONSIBILITIES AND QUALIFICATIONS TABLES

(UFP-QAPP Manual Section 2.4.3)

Identify project personnel associated with each organization, contractor, and subcontractor participating in responsible roles. Include data users, decision-makers, project managers, QA officers, project contacts for organizations involved in the project, project health and safety officers, geotechnical engineers and hydrogeologists, field operation personnel, analytical services, and data reviewers. Identify project team members with an asterisk (\*). Attach resume to this worksheet or note the location of the resumes.

☐ Worksheet Not Applicable (State Reason)

**Worksheet #7 Personnel Responsibilities and Qualification Table**

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Russell Fish	Project Manager	USEPA	Responsible for the overall management of RI <ul style="list-style-type: none"> <li>• Responsible for leading activities designed to meet objectives of the pre-design and design tasks;</li> <li>• Responsible for providing review and approval of deliverables prepared for submission to USEPA, and</li> <li>• Responsible for approval of project documents and reports.</li> </ul>	Designated as the USEPA Project Site Manager

**Worksheet #7 Personnel Responsibilities and Qualification Table**

<b>Name</b>	<b>Title</b>	<b>Organizational Affiliation</b>	<b>Responsibilities</b>	<b>Education and Experience Qualifications</b>
			Honeywell, on task matters including task status reporting.	
Jennifer Huha	Project QA Officer	Wood	<ul style="list-style-type: none"> <li>• providing periodic evaluations of field operations to verify that appropriate protocols are being used;</li> <li>• ensuring that all required and appropriate WP, SAMP, and QAPP documentation is provided to field personnel;</li> <li>• bringing any QC problems to the attention of the Program Manager and participate in the resolution of project issues; and</li> <li>• interfacing with appropriate Honeywell personnel for project QC matters, including data validation and questions relating to QA process, protocols, and compliance.</li> </ul>	Designated Wood QA Officer
John Mihalich	RI Lead	Wood	<ul style="list-style-type: none"> <li>• ensure that field activities are conducted in accordance with the WP and SAMP;</li> <li>• maintain close communication with the FOL to ensure that sampling procedures and sampling schedules are maintained;</li> <li>• prepare an RI report that accurately reflects information gathered in the field and adequately addresses concerns</li> </ul>	Designated Wood RI Leader

**Worksheet #7 Personnel Responsibilities and Qualification Table**

<b>Name</b>	<b>Title</b>	<b>Organizational Affiliation</b>	<b>Responsibilities</b>	<b>Education and Experience Qualifications</b>
			<ul style="list-style-type: none"> <li>• complete field logbook entries documenting daily activities;</li> <li>• complete all FDRs applicable to tasks assigned; and</li> <li>• communicating any nonconformance or potential data quality issues to the Wood FOL.</li> </ul>	
Charles Hartke	Laboratory QA Director	SGS Laboratories	<ul style="list-style-type: none"> <li>• approving the laboratory SOPs;</li> <li>• ensuring and improving quality within the laboratory;</li> <li>• supervising and providing guidance and training to laboratory staff;</li> <li>• addressing all client inquiries involving data quality issues;</li> <li>• performing QA audits and assessments;</li> <li>• tracking external and internal findings of QA audits; and,</li> <li>• coordinating laboratory certification and accreditation programs.</li> </ul>	Designated SGS QA Director
Rocus Peters	Laboratory Project Manager	SGS Laboratories	<ul style="list-style-type: none"> <li>• Establishing project file and analytical requirements per lab program scope of work (SOW);</li> <li>• communicating project requirements to lab personnel;</li> <li>• keeping the laboratory and client informed of project status;</li> </ul>	Designated SGS Project Manager

## QAPP WORKSHEET #10 PROBLEM DEFINITION

(UFP-QAPP Manual Section 2.5.2)

Clearly define the problem and the environmental questions that should be answered for the current investigation and develop the project decision “If..., then...” statements in the QAPP, linking data results with possible actions. The prompts below are meant to help the project team define the problem. They are not comprehensive.

☐ Worksheet Not Applicable (State Reason)

**Worksheet #10 Problem Definition**

The problem to be addressed by the project: *The objective of this project is to complete an RFI characterization of the Site as described in the Wood WP (RCRA Facility Investigation Workplan, Rev. 3, AMEC, January 2015) and any additional work plans prepared for subsequent investigations. Past investigations have included Site work, research and review of historical Site data and report generation. A Site wide CSM and individual CSMs have been developed to identify data gaps. The objectives proposed in the work scope are as follows:*

- *Complete collection of remaining data necessary to support selection of corrective measures at SWMUs noted in the March 2014 Corrective Action Framework Technical Memorandum as requiring additional investigation;*
- *Complete collection of data necessary to demonstrate the Current Human Exposures Under Control Environmental Indicator (EI) status of “Yes”;*
- *Complete collection of data necessary to demonstrate the Migration of Contaminated Groundwater Under Control EI status of “Yes”; and,*
- *Complete a Human Health Risk Assessment (RA) to provide the decisional basis for USEPA selection of corrective measures for DVW SWMUs and AOCs.*
- *Complete soil vapor survey to assess potential risk associated with vapor intrusion pathways.*

The environmental questions being asked: *The purpose of the RFI is to determine the sources of contamination at the Site and nature and extent of contamination in soil, and groundwater to the extent practical. Additionally, the goal is to complete the RFI characterization of Solid Waste Management Units (SWMUs) and areas of concern (AOCs) on DVW sufficient to evaluate potential corrective measures or to potentially identify interim measures, as necessary. The primary questions the RFI will address are: 1) What is the extent of contaminants at the Site as it relates to corrective action? 2) What are the human health risks?*

## Worksheet #11 Project Quality Objectives /Systematic Planning Process Statements

Who will use the data? <i>Wood, their subcontractors and overseeing agencies will use the data.</i>
What will the data be used for? <i>The primary objectives of this investigation are to provide current data to confirm prior results, fill data gaps, acquire a better understanding of site hydrogeology to support human health risk assessments. Additionally, the data will be used to characterize the source of contamination, characterize the potential pathways of contaminant migration, define the degree and extent of contamination, identify actual or potential human receptors, and support the development of alternatives from which corrective measures will be selected.</i>
What type of data are needed? (target analytes, analytical groups, field screening, on-site analytical or off-site laboratory techniques, sampling techniques) <i>Analytical data from soil and groundwater, will be collected from on-site areas. Depending on the Task Area investigated and sampled, samples will be potentially analyzed for Target Compound list (TCL) VOCs, SVOCs, and pesticides, and Target Analyte List (TAL) metals. Specific sampling scope for media and planned analyses are described in the WP.</i>
How “good” do the data need to be in order to support the environmental decision? <i>The quality of data needed to achieve the PQOs is described using data quality indicator goals (precision, accuracy, representativeness, comparability, completeness, selectivity, and sensitivity) required of each analytical parameter used for each media sampled. The limits set on each of these items are referred to as measurement performance criteria and are defined in Worksheets 12, 15, 24, and 35. Measurement performance have been established for each parameter in order to ensure the data are sound, highly defensible, and with low enough quantitation limits to support human health evaluations.</i>
How much data are needed? (number of samples for each analytical group, matrix, and concentration) <i>The number of samples and analyses for each media are summarized in the WP, with the following table listing the number of samples and media that will be collected at each of the SWMUs and AOCs. A summary of samples and chemical analyses planned for each SWMU is provided on Table 11-1A.</i>
Where, when, and how should the data be collected/generated? <i>Soil boring, surface soil, and monitoring well locations and sampling schedules are documented in WP. Data will be generated in accordance with sampling SOPs in Appendices A and B, analytical methods described on Table 1, and laboratory SOPs described in Appendix C.</i>
Who will collect and generate the data? <i>Wood will collect the environmental samples. Samples will be analyzed by SGS Laboratories located in Dayton, New Jersey. Field data and laboratory data will be managed and reported by Wood.</i>



How will the data be reported? *Records generated during field activities will be maintained in a project file and important field data records (Appendix B) will be included as appendices in the RI report. The analytical laboratory will provide a report stored on a CD and analytical results in an EDD. Results will be validated and entered into the Locus Technologies EIM electronic database as described in Worksheet #14. Data from EIM will be used to prepare tables and figures. Investigation data will be presented in an RFI Report in figures and tables that describe a conceptual model of conditions at the Site. Quantitative risk evaluations will also be included in the contamination assessment.*

How will the data be archived? *Field and Analytical data will be maintained in project files by Wood and Honeywell. Field records, logbooks, and other supporting records generated during field activities will be maintained in a project file. Laboratory reports will be stored as electronic copies in the project files. Analytical data will be archived in the EIM database.*

## WORKSHEETS

6. Number of site-wide groundwater samples represents the remaining site-wide wells not already accounted for under each SWMU/AOC.

**Table 11-1a Summary of Samples and Chemical Analyses - 2018**

		SOIL*	GROUNDWATER <sup>1</sup>	GROUNDWATER <sup>2</sup>	AIR
		TCL-VOCs	TCL-VOCs	TCL-VOCs	TO-15
<b>MW-6</b>	Samples	42	14	9	--
	Field Duplicates	5	2	1	--
	MS/MSD	3	1	1	--
	Equipment Blank	5	2	1	--
<b>Areas 5 and 6</b>	Samples	--	3	2	--
	Field Duplicates	--	1	1	--
	MS/MSD	--	1	1	--
	Equipment Blank	--	1	1	--
<b>Soil Gas</b>	Samples	--	--	--	8
	Field Duplicates	--	--	--	1
<b>Indoor Air</b>	Samples	--	--	--	TBD
	Field Duplicates	--	--	--	TBD
<b>Outdoor Air</b>	Samples	--	--	--	2
	Field Duplicates	--	--	--	1

\* Up to three soil samples per boring is estimated; actual number will be based on field observations.

1 – Grab groundwater samples from borings.

2 – Groundwater samples from permanent wells; additional samples to be collected from newly installed wells (actual number TBD).

TCL-VOCs - Target Compound List Volatile Organic Compounds.

TO-15 – USEPA Compendium Method TO-15.

USEPA – U.S. Environmental Protection Agency.

-- No sample collected.

MS/MSD - Matrix Spike/Matrix Spike Duplicate Analysis.

Field duplicates and Equipment Blanks will be collected at 10% frequency.

MS/MSDs will be collected at 5% frequency.

TBD – To be determined based on the results of the VISL evaluation.

Table 12-1 – Analytical Methods

Analytical Parameter	Analysis Method	Analysis Procedure	Extraction/Preparation Method	Extraction/Preparation Procedure
<b>Aqueous Methods</b>				
TCL VOCs	SW-846 8260B	GC/MS	SW-846 5030	Purge and Trap
TCL SVOCs	SW-846 8270D	GC/MS	SW-846 3520	CLL Extraction
TCL Pesticides	SW-846-8081B	GC	SW-846-3510A	Sep Funnel
TAL Metals	SW-846 6010C/7470A	ICP/CVAA	SW-846 3010	Acid Digestion
<b>Soil Methods</b>				
TCL VOCs	SW-846 8260B	GC/MS	SW-846 5035	Purge and Trap
TCL SVOCs	SW-846 8270D	GC/MS	SW-846 3550C	Sonication Extraction
TCL Pesticides	SW-846-8081B	GC	SW-846-3550C	Sonication Extraction
TAL Metals	SW-846 6010C/7471A	ICPCVAA	SW-846 3050	Acid Digestion
Copper	SW-846 6010C	ICP	SW-846 3050	Acid Digestion
<b>Air and Soil Vapor</b>				
TCL VOCs	USEPA TO-15	GC/MS	NA	Canister/Trap
<b>Waste Characterization</b>				
TCLP VOCs	SW-846 8260B	GC/MS	SW-846 1311/8260B	Purge and Trap
TCLP SVOCs	SW-846 8270D	GC/MS	SW-846 1311/8270D	Separation Funnel
TCLP Pesticides	SW-846-8081 B	GC	SW-846 1311/8081A	Separation Funnel
PCBs	SW-846 8082A	GC	SW-846 3540A	Sonication Extraction
TCLP Metals	SW-846 6010C	ICP	SW-846 1311/3010A	Acid Digestion
Cyanide	SW-846-9012B	Wet chem	SW-846-9012A	Distillation
Corrosivity	SW-846 9045	Wet chem	SW-846 9045	Method Defined
Reactivity	SW-846 9031	Wet chem	SW-846 9031	Distillation
Ignitability	SW-846 1030	Wet chem	SW-846 1030	Combustion Test

Note: All extraction, preparation, and analytical procedures shall conform to the most recently promulgated versions of EPA SW846.

VOCs- Volatile Organic Compounds

TCL – Target Compound List

MS - Mass Spectrometer

SVOC – Semivolatile Organic Compounds

TAL – Target Analyte List

CLL - Continuous Liquid-Liquid

PCBs – Polychlorinated biphenyls

TCLP – Toxicity Characterization Leaching Procedure

ICP - Inductively Coupled Plasma

## WORKSHEET #12 MEASUREMENT PERFORMANCE CRITERIA TABLE

<b>Matrix</b>	Air and Soil Vapor				
<b>Analytical Group</b>	TCL VOC				
<b>Concentration Level</b>	Low				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&amp;A)</b>
S-17	USEPA TO-15, L-17	Precision - Overall	RPD $\leq$ 30 when one result is $\geq$ 2x RL (reporting limit) No situations where one result is detected at $\geq$ 2x RL and other result is not detected.	Field Duplicates	S & A
		Accuracy/Bias	Percent recoveries 70 - 130	Laboratory Control Sample	A
		Accuracy/Bias	Percent recoveries 70 - 130	Surrogates	A
		Accuracy/Bias	50 to 200% of calibration standard. Retention time within 30 seconds of calibration standard	Internal Standards	A
		Accuracy/Bias - Contamination	No target compounds > RL (except for common lab contaminants)	Method Blanks Equipment Blanks Trip Blanks	S & A
		Completeness	90% - Assessment of impact on project objectives made regarding missing or rejected sample data.	Data Completeness Check	S & A
		Sensitivity	MDL/RL evaluated versus project action limits. See Worksheet #15	MDL Study	A

**Worksheet # 14 Summary of Project Tasks**

Matrix codes for this project will be as follows:

SS = Surface soil sample  
SB = Soil sample from soil boring location  
MW = Monitoring well groundwater  
IA = Indoor air sample  
OA = Outdoor air sample  
SV = Soil vapor sample  
EB = Equipment Blank  
TB = Trip Blank

**Worksheet # 14 Summary of Project Tasks**

Example sample designations are shown below:

- Soil boring samples collected from the first boring at SMWU 2 and collected at a depth of 2-4 ft below ground surface (bgs) will be labeled as SB02-01 (2-4).
- Surface soil samples collected from location 1 and collected at a depth of 0-2 ft bgs will be labeled as SS-01 (0-2).
- Groundwater samples collected from existing monitoring well MW-53 at SMWU 1 collected on August 1, 2014 will be labeled as MW53-01-080114
- Soil gas samples from location SV-1 collected on August 1, 2018 will be labeled SV-1. Outdoor air samples from location OA-1 collected on August 10, 2018 will be labeled OA-1. Indoor air samples from location IA-1 collected on August 20, 2018 will be labeled IA-1.

The sample ID code is not limited to a specific number of digits, except for practical limitations in listing the sample ID in report tables. Sample IDs will be assigned as described below:

- Sample ID formats are also specified for field duplicates and field QC blanks. Equipment blank sample IDs will include related media, EB code, and numbered sequentially with the collection data appended to the end. EB01-date. Trip blank sample IDs will be numbered sequentially with the shipping data appended to the end. TB01-date
- Samples may also be identified as MS/MSD in the comments of the chain of custody forms, but MS/MSD samples will have the same sample ID as the parent sample.
- To designate a field duplicate sample, -DUP will be added to the end of the Sample ID.

- sample depths (if not recorded on a FDR)
- whether grab or composite sample collected (if not recorded on a FDR)
- sample description (color, odor, texture, etc.) (if not recorded on a FDR)
- tests or analyses to be performed (if not recorded on a FDR)
- sample preservation and storage conditions (if not recorded on a FDR)
- equipment decontamination activities
- QC sample collection
- record of photographs if taken
- sketches or diagrams
- signature of person recording the information

Field logbooks will be reviewed on a daily basis by the Wood Field Operations Leader at the beginning of each field task to verify that proper record keeping procedures are being followed. Logbooks will be reviewed periodically after that based on the judgment of the FOL.

Field Data Record Forms:

Field data records will be used to record sample collection information in real time during field activities. A complete set of Field Data Records is provided in Appendix B of the QAPP (and the RI Work Plan/FSP). These forms are designed to capture data from each type of field activity that is completed during the RI. Field personnel are instructed to utilize these forms during the field activities for which each form was designed.

- Field Equipment Calibration Record
- Low Flow Groundwater Sampling Record
- Soil Boring Log
- Surface Soil Sampling Record
- Well Development Record
- Soil Vapor Point Construction Diagram
- Air and Soil Vapor Sampling Record
- Flush Well Construction Diagram
- Stick Up Well Construction Diagram
- Chain of Custody Form

**QAPP WORKSHEET #15 CONTAMINANTS OF CONCERN AND OTHER TARGET ANALYTES TABLE (REFERENCE LIMITS AND EVALUATION TABLE)**

(UFP-QAPP Manual Section 2.8.1) ☐ Worksheet Not Applicable (State Reason)

Complete this worksheet for each matrix, analytical group, and concentration level. Identify the target analytes/contaminants of concern and project-required action limits. Next, determine the quantitation limits (QLs) that must be met to achieve the project quality objectives. Finally, list the published and achievable detection and quantitation limits for each analyte.

A detailed summary of the RCRA Facility Investigation sampling program is described the WP and additional work plans prepared for specific tasks. Samples will be collected from the following media:

- Soil
- Groundwater
- Indoor Air
- Outdoor Air
- Soil Vapor

**The Analytical Approach**

Goals for analytical method sensitivity include the identification of Project Quantitation Limits (PQLs) based on laboratory method detection limits (MDLs) and laboratory RLs. PQLs presented in Worksheet 15 have been established for each parameter based on detection limit information provided by the laboratory. In accordance the UFP-QAPP format, Project Action Limits (PALs) are also identified for each parameter. In accordance with procedures under RCRA, applicable risk screening levels are identified based on regulatory guidelines for human health. Analytical results from the RI sampling events will be compared to the following federal criteria listed on Worksheet 15. The PAL values were obtained from the following sources:



### Groundwater PALs

The groundwater PAL for each chemical is from the following sources:

- USEPA. May 2018. Regional Screening Level (RSL) Summary Table (TR=1E-6, HQ=1). MCLs or Tap Water if no MCL exists.
- <https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables> **USEPA Maximum Contaminant Levels (MCLs)**

### Soil PALs

The soil PALs were obtained from the following sources:

- USEPA. May 2018. Regional Screening Level (RSL) Summary Table (TR=1E-6, HQ=1). Protection of Groundwater SSLs, MCL-based SSL or Risk-based SSL if there is no MCL-based SSL, assuming EPA's default dilution attenuation factor of 20.  
<https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>

### Air and Soil Vapor PALs

The air and soil vapor PALs were obtained from the following sources:

- USEPA. May 2018. The Vapor Intrusion Screening Level (VISL) calculator Commercial Soil Gas and Indoor Air.

Detections limits established for this project are consistent with low and low/medium concentration methods used during early Phase I and Phase II investigations under RCRA to test for a broad range of analytes. These methods have detection limits similar to routine USEPA Contract Laboratory Program (CLP) methods and are designed to provide information on the nature of contamination for a large suite of analytes. Analytical methods include target compounds/analytes identified in the USEPA CLP TCL and TAL. Detection limits for analytes are established in accordance with USEPA SW-846 methods and are designed to test for trace concentrations. Detection limits are identified as MDLs and RLs. Human health risk based concentration (RSLs) and MCLs for water samples listed on Worksheet 15 are based on USEPA Region 3 guidelines. In some cases the RSLs are set at very low concentrations that are lower than the RLs or MDLs established for the analytical methods. Analytes that have RSLs less than the RLs and MDLs are shaded values on Worksheet 15. The primary chemical

Matrix: Air

Analytical Group: VOCs TO-15

Concentration Level: Low/Medium

Matrix: Air		Analytical Group: VOA TO-15		Concentration Level: Low			
CAS No.	Analyte	Commercial Sub-Slab and Near-Source Soil Gas Screening Levels (µg/m3) <sup>1</sup>	Commercial indoor Air Screening Levels (µg/m3) <sup>2</sup>	Analytical Method Limits		Achievable Laboratory Limits	
				MDL (µg/m3)	QL (µg/m3)	RL (µg/m3)	MDL (µg/m3)
67-64-1	Acetone	451,000	13,500	NA	NA	0.48	0.15
106-99-0	1,3-Butadiene	13.6	0.409	NA	NA	0.44	0.062
71-43-2	Benzene	52.4	1.57	NA	NA	0.64	0.082
75-27-4	Bromodichloromethane	11	0.331	NA	NA	1.3	0.19
75-25-2	Bromoform	3,72	11.1	NA	NA	2.1	0.18
74-83-9	Bromomethane	73	02.19	NA	NA	0.78	0.13
593-60-2	Bromoethene	12.8	.383	NA	NA	0.87	0.068
100-44-7	Benzyl Chloride	8.4	0.25	NA	NA	1	0.11
75-15-0	Carbon disulfide	102,000	3,070	NA	NA	0.62	0.1
108-90-7	Chlorobenzene	730	21.9	NA	NA	0.92	0.079
75-00-3	Chloroethane	146,000	4,380	NA	NA	0.53	0.094
67-66-3	Chloroform	17.8	.533	NA	NA	0.98	0.15
74-87-3	Chloromethane	1,310	39.4	NA	NA	0.41	0.13
107-05-1	3-Chloropropene	14.6	.438	NA	NA	0.63	0.12
95-49-8	2-Chlorotoluene			NA	NA	1	0.19

56-23-5	Carbon tetrachloride	68.1	2.4	NA	NA	1.3	0.13
110-82-7	Cyclohexane	87,600	2,630	NA	NA	0.69	0.12
75-34-3	1,1-Dichloroethane	256.0	7.67	NA	NA	0.81	0.13
75-35-4	1,1-Dichloroethylene	2,920	87.6	NA	NA	0.79	0.13
106-93-4	1,2-Dibromoethane	0.681	0.0204	NA	NA	1.5	0.17
107-06-2	1,2-Dichloroethane	157	4.72	NA	NA	0.81	0.11
78-87-5	1,2-Dichloropropane	584	17.5	NA	NA	0.92	0.15
123-91-1	1,4-Dioxane	818	24.5	NA	NA	0.72	0.17
75-71-8	Dichlorodifluoromethane	1,460	43.8	NA	NA	0.99	0.13
124-48-1	Dibromochloromethane			NA	NA	1.7	0.21
156-60-5	trans-1,2-Dichloroethylene			NA	NA	0.79	0.1
156-59-2	cis-1,2-Dichloroethylene			NA	NA	0.79	0.13
10061-01-5	cis-1,3-Dichloropropene	1,020	30.7	NA	NA	0.91	0.11
541-73-1	m-Dichlorobenzene			NA	NA	1.2	0.17
95-50-1	o-Dichlorobenzene	2,920	87.6	NA	NA	1.2	0.17
106-46-7	p-Dichlorobenzene	37.2	1.1	NA	NA	1.2	0.17
10061-02-6	trans-1,3-Dichloropropene	1,020	30.7	NA	NA	0.91	0.13
64-17-5	Ethanol			NA	NA	0.94	0.18
100-41-4	Ethylbenzene	164	4.91	NA	NA	0.87	0.099
141-78-6	Ethyl Acetate	117	3.5	NA	NA	0.72	0.23
622-96-8	4-Ethyltoluene			NA	NA	0.98	0.14
76-13-1	Freon 113	73,000	2,190	NA	NA	1.5	0.18
76-14-2	Freon 114			NA	NA	1.4	0.17
142-82-5	Heptane	5,840	175	NA	NA	0.82	0.19
87-68-3	Hexachlorobutadiene	186	5.57	NA	NA	2.1	0.26
110-54-3	Hexane	10,200	307	NA	NA	0.7	0.093

591-78-6	2-Hexanone	438	13.1	NA	NA	0.82	0.17
67-63-0	Isopropyl Alcohol	2920	87.6	NA	NA	0.49	0.22
75-09-2	Methylene chloride	8,760	263	NA	NA	0.69	0.11
78-93-3	Methyl ethyl ketone	73,000	2,190	NA	NA	0.59	0.13
108-10-1	Methyl Isobutyl Ketone	43,800	1,310	NA	NA	0.82	0.23
1634-04-4	Methyl Tert Butyl Ether	1,570	47.2	NA	NA	0.72	0.068
80-62-6	Methylmethacrylate	10,200	307	NA	NA	0.82	0.18
115-07-1	Propylene	43,800	1,310	NA	NA	0.86	0.1
100-42-5	Styrene	14,600	438	NA	NA	0.85	0.19
71-55-6	1,1,1-Trichloroethane	73,000	2,190	NA	NA	1.1	0.093
79-34-5	1,1,2,2-Tetrachloroethane	7.05	0.211	NA	NA	1.4	0.25
79-00-5	1,1,2-Trichloroethane	2.92	0.0876	NA	NA	1.1	0.12
120-82-1	1,2,4-Trichlorobenzene	29.2	0.876	NA	NA	1.5	0.29
95-63-6	1,2,4-Trimethylbenzene	876	26.3	NA	NA	0.98	0.25
108-67-8	1,3,5-Trimethylbenzene	876	26.3	NA	NA	0.98	0.15
540-84-1	2,2,4-Trimethylpentane			NA	NA	0.93	0.12
75-65-0	Tertiary Butyl Alcohol			NA	NA	0.61	0.08
127-18-4	Tetrachloroethylene	584	17.5	NA	NA	0.27	0.11
109-99-9	Tetrahydrofuran	29,200	876	NA	NA	0.59	0.13
108-88-3	Toluene	73,000	2,190	NA	NA	0.75	0.11
79-01-6	Trichloroethylene	29.2	0.876	NA	NA	0.21	0.063
75-69-4	Trichlorofluoromethane			NA	NA	1.1	0.084
75-01-4	Vinyl chloride	92.9	2.79	NA	NA	0.51	0.097
108-05-4	Vinyl Acetate	2,920	87.6	NA	NA	0.7	0.096
	m,p-Xylene	1,460	43.8	NA	NA	0.87	0.29
95-47-6	o-Xylene	1,460	43.8	NA	NA	0.87	0.15
1330-20-7	Xylenes (total)	1,460	43.8	NA	NA	0.87	0.15

Notes:

VAPOR INTRUSION SCREENING LEVEL (VISL) CALCULATOR

1. Target Sub-Slab and Near-Source Soil Gas Concentration (TCR=1E-0 or THQ=.1)  $C_{sq}$ , Target
2. Target Indoor Air Concentration (TCR=1E-06 or THQ=.1)  $C_{sq}$ , MIN ( $C_{ia}$ ,  $C_{ia,nc}$ )

**QAPP WORKSHEET #17 SAMPLING DESIGN AND RATIONALE**

(UFP-QAPP Section 3.1.1)

Describe the project sampling approach. Provide the rationale for selecting sample locations and matrices for each analytical group and concentration level.

☐ Worksheet Not Applicable (State Reason)

**Worksheet # 17 Sampling Design and Rationale**

Describe and provide a rationale for choosing the sampling approach (e.g., grid system, biased statistical approach): Table I-1 in the WP presents a sample summary table. This table presents the status of each SWMU the number, location, and identifications of each proposed sampling depth, the number and types of parameters to be analyzed for, as well as the rationale for these activities. This table provides this information for each individual SWMU as well as for the Site-wide pesticide, groundwater and hydrogeologic portions of the RFI. The analytical parameters were selected for each SWMU/AOC based on known wastes managed in the unit and historical data generated by the Phase I and Phase II RFI work completed previously.

In addition to each SWMU/AOC, pesticides in surface soil and groundwater quality and hydrogeology will be assessed on a site-wide basis. The initial groundwater investigation will focus on an assessment of groundwater quality. This assessment will be accomplished using monitoring wells. The monitoring wells installed during this phase of investigation will be screened across the water table to determine groundwater quality and will be designed to monitor light, non-aqueous phase liquid thickness, if encountered. The groundwater assessment will be performed after boring installation to allow the soil screening information to be incorporated into the monitoring well location selection process. The need to install additional monitoring wells for horizontal and/or vertical delineation of groundwater impact and possible occurrence of DNAPL will be evaluated upon completion of this investigation, on an as needed basis.

Describe the sampling design and rationale in terms of what matrices will be sampled, what analytical groups will be analyzed and at what concentration levels, the sampling locations (including QC, critical, and background samples), the number of samples to be taken, and the sampling frequency (including seasonal considerations) [May refer to map or Worksheet #18 for details]: Table I-1 in the WP addresses these issues. The WP evaluates site sources and pathways to human health, environment and ecological receptors from potentially contaminated surface/subsurface soil and groundwater. The WP was based on investigations already completed, data previously collected and the updated CSM. Additional investigations for VOCs in soil, groundwater, soil gas, outdoor air, and indoor air are described in the Work Plan.

**QAPP WORKSHEET #18 SAMPLING LOCATIONS AND METHODS/SOP REQUIREMENTS TABLE**

(UFP-QAPP Manual Section 3.1.1)

List all site locations that will be sampled and include sample/ID number, if available. (Provide a range of sampling locations or ID numbers if a site has a large number.) Specify matrix and, if applicable, depth at which samples will be taken. Only a short reference for the sampling location rationale is necessary for the table. The text of the QAPP should clearly identify the detailed rationale associated with each reference. Complete all required information, using additional worksheets if necessary.

☐ Worksheet Not Applicable (State Reason)

**Worksheet # 18 Sampling Locations and Methods/SOP Requirements Table**

Information on sampling locations, sample ID's, matrices, depths, analytical groups, numbers of samples, and rational for sample collection are included in the WP. Sample collection SOPs are found in Appendix A. The following WP has been prepared for the sampling events:

Wood E&SI, 2018. WP- Honeywell Delaware Valley Works, Claymont, Delaware, for Honeywell, July 2018.

Table I-1 in the WP presents a sample summary table. This table presents the status of each SWMU, the number, location, and identifications of each proposed sampling depth, the number and types of parameters to be analyzed for, as well as the rationale for these activities.

## QAPP WORKSHEET #19 ANALYTICAL SOP REQUIREMENTS TABLE

(UFP-QAPP Manual Section 3.1.1)

For each matrix, analytical group, and concentration level, list the analytical and preparation method/SOP and associated sample volume, container specifications, preservation requirements, and maximum holding time.

☐ Worksheet Not Applicable (State Reason)

Worksheet # 19 Analytical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method /SOP Reference <sup>1</sup>	Sample Volume	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation /analysis)
GW	TCL VOCs	Low	SW-846 8260B / L-1	3 x 40 ml	3 x 40 ml volatile organic analysis (VOA) vials with Teflon septum	pH < 2 w/HCl: No headspace, no bubbles; Cool, 4°C	14 days to analysis
Soil	TCL VOCs	Low/High	SW-846 5035 / 8260B / L-1	3 x 40ml and (1) 2oz jar for % solids	3 x 40ml (2 with DI water/sodium bisulfate, 1 with methanol) with Teflon septum	Low-Conc: 5 ml DI water/sodium bisulfate with stir bar, 4°C. High-Conc: 10 ml methanol, 4°C.	14 days to analysis
Air/Soil Vapor	TCL VOCs	Low/High	USEPA TO-15 / L-16, L-17	6-liter	Summa canister		14 days to analysis



## QAPP Worksheet #20 Field Quality Control Sample Summary Table

(UFP-QAPP Manual Section 3.1.1)

Summarize by matrix, analytical group, and concentration level the number of field QC samples that will be collected and sent to the laboratory.

☐ Worksheet Not Applicable (State Reason)

Worksheet # 20 Field Quality Control Sample Summary Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference <sup>1</sup>	No. of Sampling Locations	No. of Field Duplicate Pairs	No. of MS /MSD	No. of Field Blanks*	No. of Equip. Blanks	No. of PT Samples	Total No. of Samples to Lab*
Groundwater	VOC	Low	L-1	See SAMP Part II	10%	5%	1	10%	0	See SAMP Part II
Soil	VOC	Low/High	L-1	See SAMP Part II	10%	5%	1	10%	0	See SAMP Part II
Air/Soil Vapor	VOC	Low/High	L-17	See SAMP Part II	10%	5%	1	0	0	See SAMP Part II
Groundwater	SVOC	Low	L-2 and L-3	See SAMP Part II	10%	5%	1	10%	0	See SAMP Part II
Soil	SVOC	Low/Medium	L-2 and L-6	See SAMP Part II	10%	5%	1	10%	0	See SAMP Part II
Groundwater	Pesticides	Low/Medium	L-4, L-3	See SAMP Part II	10%	5%	1	10%	0	See SAMP Part II
Soil	Pesticides	Low/Medium	L-4, L-6, L-7, L-10	See SAMP Part II	10%	5%	1	10%	0	See SAMP Part II

Worksheet # 21 Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Check if yes)	Comments
S-15	SOP No. S-15, Geoprobe® Direct Push Sampling	Wood	Geoprobe, sampling equipment, Direct push rods, non-petroleum based lubricants, Geo-Pump peristaltic pump, Decontamination equipment, Investigation derived waste, Drums, Personal protective equipment	N	None
S-16	SOP No. S-16, Calibration Procedure for PID	Wood	Photo ionization detector, Zero gas cylinder, Span gas cylinder, Field Instrument Calibration Record (See Appendix B), Field logbook	N	None
S-17	SOP No. S-17, Substructure Soil Vapor, Soil Vapor, or Ambient Air Sampling	Wood		N	None

Worksheet # 23 Analytical SOP References Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
L-8	Removal of Sulfur from Organic Extract using Activated Elemental Copper	Definitive	Pesticides/PCBs	NA	SGS Laboratories	N
L-9	Sulfuric Acid / Permanganate Cleanup	Definitive	PCBs	NA	SGS Laboratories	N
L-10	Florisil Column Cleanup	Definitive	Pesticides/PCBs	NA	SGS Laboratories	N
L-11	Metals by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP) using Solid State ICP	Definitive	Metals	ICP-AES	SGS Laboratories	N
L-12	Digestion of Non-potable waters for ICP or ICP-MS Analysis	Definitive	Metals	Beaker	SGS Laboratories	N
L-13	Digestion of Soils for ICP and ICP-MS Analysis	Definitive	Metals	Beaker/hotplate	SGS Laboratories	N
L-14	Cold Vapor Analysis of Mercury for Water Samples	Definitive	Mercury	CVAA	SGS Laboratories	N
L-15	Cold Vapor Analysis of Mercury for Soil Samples	Definitive	Mercury	CVAA	SGS Laboratories	N
L-16	Summa Canister Cleaning and Certification	Definitive	VOCs	GC/MS	SGS Laboratories	N
L-17	Air Analysis by TO-15	Definitive	VOCs	GC/MS	SGS Laboratories	N

Extract cleanup methods are included for possible use by the laboratory in the event that matrix interference is present in samples. The need for cleanup steps will be determined by the lab under advisement by the Wood Project chemist and Project QC Officer

AES = Atomic Emission Spectrometry

## QAPP WORKSHEET #31 PLANNED PROJECT ASSESSMENTS TABLE

(UFP-QAPP Manual Section 4.1.1)

Identify the type, frequency, and responsible parties of planned assessment activities that will be performed for the project.

☐ Worksheet Not Applicable (State Reason)

## Worksheet # 31 Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Person(s) Responsible for Responding to Assessment Findings (Title and Organizational Affiliation)	Person(s) Responsible for Identifying and Implementing Corrective Actions (CA) (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (Title and Organizational Affiliation)
Field Sampling Technical Review	At beginning of sampling events	Internal	Wood	Jennifer Huha, Project QA Officer (Wood)	Field Operations Leader, scientists, and field technicians	Richard Karr, Project Manager (Wood)	Jennifer Huha, Project QA Officer (Wood)
Fixed Laboratory Technical Systems Audit (if required)	None scheduled	External	Wood	Chris Ricardi, Project Chemist (Wood)	Charles Hartke, Laboratory QA Director, SGS Laboratories	Charles Hartke, Laboratory QA Director, SGS Laboratories	Jennifer Huha, Project QA Officer (Wood)
Field Health and Safety Systems Review	At beginning of sampling events	Internal	Wood	Designated Project Safety Officer TBD	Field Operations Leader, scientists, and field technicians	Richard Karr, Project Manager (Wood)	John Mihalich, RI Lead

**QAPP WORKSHEET #32 ASSESSMENT FINDINGS AND CORRECTIVE ACTION RESPONSES**

(UFP-QAPP Manual Section 4.1.2)

For each type of assessment describe procedures for handling QAPP and project deviations encountered during the planned project assessments.

☐ Worksheet Not Applicable (State Reason)

**Worksheet # 32 Assessment Findings and Corrective Action Responses**

<b>Assessment Type</b>	<b>Nature of Deficiencies Documentation</b>	<b>Individual(s) Notified of Findings (Name, Title, Organization)</b>	<b>Timeframe of Notification</b>	<b>Nature of Corrective Action Response Documentation</b>	<b>Individual(s) Receiving Corrective Action Response (Name, Title, Org.)</b>	<b>Timeframe for Response</b>
Field Sampling Technical System Review	Verbal Summary and Memorandum	Wood PM, RI Lead, FOL and Field Crew Members	Immediate verbal, mem within 72 hours after discovery	Personal communications followed by Email or Memorandum	Jennifer Huha, Project QA Officer Wood)	Immediate field response with possible written documentation
Fixed Laboratory Technical Systems Audit (if required)	Audit Findings Report	Charles Hartke, Laboratory QA Director, SGS Laboratories	One week after audit	Memorandum	Jennifer Huha, Project QA Officer Wood)	48 hours after notification
Field Health and Safety Systems Review)	Verbal Summary and Memorandum	Wood PM, RI Lead, FOL and Field Crew Members	Immediate verbal, memo within 24 hours after discovery	Personal communications followed by Email or Memorandum	John Mihalich, RI Lead	Immediate field response with possible written documentation

**QAPP WORKSHEET #33 QA MANAGEMENT REPORTS TABLE**

(UFP-QAPP Manual Section 4.2)

Identify the frequency and type of planned QA Management Reports, the projected delivery date, the personnel responsible for report preparation, and the report recipients.

☐ Worksheet Not Applicable (State Reason)

**Worksheet # 33 QA Management Reports Table**

<b>Type of Report</b>	<b>Frequency (daily, weekly monthly, quarterly, annually, etc.)</b>	<b>Projected Delivery Date(s)</b>	<b>Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)</b>	<b>Report Recipient(s) (Title and Organizational Affiliation)</b>
Verbal Status Report	As needed to document progress of field program	TBD	RI Lead and Field Operations Leader	Richard Karr, Project Manager, Wood John Mihalich, RI Leader
Verbal or Written Status Report	As necessary	As necessary	Richard Karr, Project Manager Wood	Steve Coladonato, Honeywell, Erich Weissbart, USEPA Region III, Larry Matson, DNREC Representative, James Wentzel, PADEP Representative
Corrective Action Report	As necessary	As necessary	Jennifer Huha, Project QA Officer Wood)	Richard Karr, Project Manager Wood
Field Sampling Technical Systems Review	One/ at startup of sampling	Confirmation Memo/email within 48 hours	Jennifer Huha, Project QA Officer Wood)	Richard Karr, Project Manager, Wood,
Field Operations Health and Safety Review	One/ at startup of sampling	Confirmation Memo/email within 48 hours	John Mihalich, RI Lead	Richard Karr, Project Manager, Wood,
Data Usability Assessment	One/ after all data generated and validated	TBD	Chris Ricardi, Project Chemist	Richard Karr, Project Manager, Wood,

## QAPP WORKSHEET #34 VERIFICATION (STEP I) PROCESS TABLE

(UFP-QAPP Manual Section 5.2.1)

Describe the processes that will be followed to verify project data. Verification inputs include items such as those listed in Table 9 of the UFP-QAPP Manual (Section 5.1). Describe how each item will be verified, when the activity will occur, and what documentation is necessary, and identify the persons responsible. *Internal* or *external* is in relation to the data generator.

☐ Worksheet Not Applicable (State Reason)

## Worksheet # 34 Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
COCs and Shipping Forms	Chain-of-Custody forms and shipping documentation will be reviewed to verify completeness in accordance with QAPP requirements and verified against the packed sample coolers for which they represent. When everything checks out, a copy of the COC will be retained in the site file, and the original and remaining copies will be taped inside the cooler for shipment.	Internal	TBD, Wood FOL, and SGS Laboratories
Field Logbooks and FDRs	Field records will be reviewed on a daily basis by the FOL to ensure notes are accurate and applicable FDR forms are complete.	Internal	TDB Wood FOL, John Mihalich RI Lead, Jennifer Huha, Project QA Officer Wood
Field Systems and Health and Safety Review Documents	Reviews will be documented via email or memorandum and copies will be placed in the project file. If corrective actions are required, a summary of the corrective action taken will be included. Field Reviews will be reviewed that appropriate corrective actions have been taken and that corrective action reports are attached.	Internal	Richard Karr, Project Manager Wood
Laboratory Data Packages*	All laboratory data packages will be reviewed for completeness and accuracy internally by the laboratory performing the work prior to submittal.	Internal	SGS Laboratories
Laboratory Data Packages	All final laboratory data packages will be verified for content upon receipt.	External	Chris Ricardi, Wood Project Chemist

## QAPP WORKSHEET #35 VALIDATION (STEPS IIA AND IIB) PROCESS TABLE

(UFP-QAPP Manual Section 5.2.2)

Describe the processes that will be followed to validate project data. Validation inputs include items such as those listed in Table 9 of the UFP-QAPP Manual (Section 5.1). Describe how each item will be validated, when the activity will occur, and what documentation is necessary and identify the person responsible. Differentiate between steps Iia and Iib of validation.

☐ Worksheet Not Applicable (State Reason)

## Worksheet # 35 Validation (Steps Iia and Iib) Process Table

Step Iia/Iib	Validation Input	Description	Responsible for Validation (Name, Organization)
Iia	Sampling Methods and Procedures	Field Sampling Technical Review completed at the beginning of field sampling event to verify WP, SAMP, and QAPP objectives, documentation, and field procedures are followed. Establish that required sampling methods were used and that any deviations were noted. Provide that the sampling procedures and field measurements met performance criteria and that any deviations were documented.	Jennifer Huha, Project QA Officer, Wood; John Mihalich, RI Lead; TBD FOL
Iia	Analytical Method and Procedures	Establish that required analytical methods were used and that any deviations were noted. The laboratory will provide that QC samples met performance criteria and that any deviations were documented in the report.	Rocus Peters Laboratory Project Manager, SGS Laboratories, Chris Ricardi Wood Project Chemist
Iib	Documentation of QAPP QC Sample Results	Establish that all QAPP required QC samples were collected and analyzed.	Jennifer Huha, Project QA Officer, Wood; John Mihalich, RI Lead; TBD FOL
Iib	Project Quantitation Limits	Determine that the project quantitation limits, outlined in the QAPP, were achieved.	Chris Ricardi Wood Project Chemist
Iib	Performance Criteria	Evaluate QC data associated with the samples designated in Worksheet #36 against project specific performance criteria established in the QAPP and laboratory Quality Assurance Manual.	Chris Ricardi Wood Project Chemist
Iib	Validation Report	Summarize data verification and validation components included in the Performance Review. Include finalized, qualified data and explanation of all qualifiers.	Chris Ricardi Wood Project Chemist



## **Appendix A Field Sampling SOPs**

- **S-1 Low-Flow/Low-Stress Groundwater Sampling**
- **S-2 Surface Soil Sampling**
- **S-3 Calibration of Field Instrumentation for Water Quality Parameters**
- **S-4 Decontamination of Field Equipment**
- **S-5 Monitoring Well Development**
- **S-6 Procedures for Measuring Groundwater Levels**
- **S-7 Sample Packaging And Shipment**
- **S-8 Sample Chain of Custody Procedure**
- **S-9 Use of Field Logbooks**
- **S-10 Procedure for Description and Identification of Soils**
- **S-11 Monitoring Well and Piezometer Installation Procedures**
- **S-12 Field Preservation of VOA and GRO Soil Samples**
- **S-13 Soil Headspace Screening Procedure**
- **S-14 Split Spoon Subsurface Sample Collection and Standard Penetration Test Procedure**
- **S-15 GeoProbe Direct Push Sampling**
- **S-16 Calibration Procedure for PID**
- **S-17 Substructure Soil Vapor, Soil Vapor, or Ambient Air Sampling**

**Appendix B  
Field Data Records**

- **Field Instrument Calibration Record**
- **Low Flow Groundwater Sampling Record**
- **Soil Boring Log**
- **Surface Soil Sampling Record**
- **Well Development Record**
- **Soil Vapor Construction Diagram**
- **Air and Soil Vapor Sampling Record**
- **Flush Well Construction Diagram**
- **Stick Up Well Construction Diagram**
- **COC Record**

## **Appendix C Laboratory SOPs**

- **L-1 Volatile Organic Compound**
- **L-2 Semi Volatile Organic Compounds**
- **L-3 3510C LL Extraction**
- **L-4 8081B Pesticides**
- **L-5 8082A PCBs**
- **L-6 3550C Sonication**
- **L-7 3546 Microwave Extraction**
- **L-8 3660B Sulfur Cleanup**
- **L-9 3665A SAcid Permanganate Cleanup**
- **L-10 3620C Florisil Cleanup**
- **L-11 6010C ICP**
- **L-12 3050B ICP Digestion Water**
- **L-13 3050B ICP Digestion Soils**
- **L-14 7470A Mercury Aqueous**
- **L-15 7471B Mercury in Soil**
- **L-16 Summa Canister Cleaning and Certification**
- **L-17 Air Analysis by TO-15**

**SOP No. S-17**

**WOOD ENVIRONMENT AND INFRASTRUCTURE SOLUTIONS, INC. STANDARD  
OPERATING PROCEDURE**

**SUBSTRUCTURE SOIL VAPOR, SOIL VAPOR, OR AMBIENT AIR SAMPLING**

## **STANDARD OPERATING PROCEDURE**

### **SUBSTRUCTURE SOIL VAPOR, SOIL VAPOR, OR AMBIENT AIR SAMPLING**

#### **1.0 SCOPE AND APPLICABILITY**

This Standard Operating Procedure (SOP) describes the methods to be used for substructure soil vapor, soil vapor, and/or ambient air sampling used to evaluate human exposure to VOCs through vapor intrusion. The equipment may include SUMMA<sup>®</sup> canisters, flow controllers, vacuum gauges, hammer drill, or any other type of equipment used during field activities.

#### **2.0 RESPONSIBILITIES**

It is the primary responsibility of the project Field Operations Leader and field samplers to assure that the proper sampling procedures are followed and that all field data records are completed.

It is the responsibility of the project safety officer to draft and enforce safety measures which provide the best protection for all persons involved directly with sampling.

It is the responsibility of any subcontractors (i.e., drilling contractors) to follow the proper designated sampling procedures that are stated in their contracts and outlined in the Project Health and Safety Plan. It is the responsibility of all personnel involved with sample collection to maintain a clean working environment and to ensure that all procedures are followed.

#### **3.0 PROCEDURES**

##### **3.1 8-Hour Substructure Soil Vapor Sampling**

Substructure soil vapor samples will be collected from beneath residential, commercial, industrial, institutional, and multiuse buildings using SUMMA<sup>®</sup> type air canisters equipped with metering flow controllers for collecting a "time-averaged" soil vapor sample. This technique is intended for 8-hour sample collection and may be collected in conjunction with indoor air samples. In some instances, 20-minute grab soil vapor samples will be permitted to identify potential VOC contamination beneath the slab (See Subsection 4.5.5.2). The SUMMA<sup>®</sup> type air canisters and pressure gauge with integrated 8-hour metering valves will be provided by the laboratory and will be supplied with documentation certifying that they are

clean. Reporting limits of certification must be equivalent or lower than sample analysis reporting limits. Substructure soil vapor samples may be collected from one of the following areas:

- Area 1) Sub slab soil vapor sample obtained via a temporary installed sampling port through apparent vapor barrier (such as floor slab or plastic liner) or via boring installed with a truck-mounted Geoprobe® using angle drilling techniques for near-slab soil vapor samples; or
- Area 2) Air sample obtained from crawl space or basement without an apparent vapor barrier.

Substructure soil vapor grab sampling will require the following equipment:

- 6-liter, stainless steel, pre-evacuated SUMMA®-type canister - laboratory provided
- Pressure gauge with integrated 8-hour metering valve - laboratory provided
- Two, 9/16-inch, open-end wrenches
- PID – part per billion range -for screening crawl space/cracks
- Utility Knife
- Electric hammer drill with 1-inch and 5/8-inch diameter drill bits for sub-slab samples or track-mounted Geoprobe® for near-slab samples
- Two 50-ft long electrical extension cords
- ¼-inch O.D. Teflon® tubing
- 3/8-inch O.D. Teflon® tubing
- 5/8 -inch O.D. Teflon® tubing
- ¼-inch stainless steel valve and stainless steel "tee" type fitting
- Vapor pin kit (vapor pin, T-handle, vapor pin caps, dead blow hammer)
- Helium Canister(s)
- Shroud (~20-gallon clear plastic tub, ~20"x12"x16", big enough to fit summa can with flow controller) 2 holes in one side for He detector probe and 1/4" tubing and 1 hole in opposite side for tubing from He canister
- 60 cc polyethylene syringe for purging tubing
- 1-inch diameter laboratory grade rubber stopper with ¼-inch port
- Thermometer/barometer
- Unscented beeswax, pan, and heat plate, or other approved seal.
- Quick-drying expansive Portland cement
- Wristwatch
- Flashlight

- COC form - laboratory provided

### **Procedure for Substructure Soil Vapor Sample Collection:**

The procedures for substructure soil vapor sample collections will be dependent on location category. During the occupant/owner interview and building survey the lowest accessible portion of the building (e.g., crawl space, basement, first floor of slab-on-grade construction, or near-slab) will be observed to assess which substructure sampling area category is applicable. The steps provided below should be considered a general guidance on the collection of substructure soil vapor samples for each location category; the sequence can be modified as needed based on site- or project-specific conditions at the time of sample collection.

**Area 1:** Sub slab soil vapor sample obtained via temporary installed sampling port through apparent vapor barrier (i.e. floor slab or plastic liner).

#### **1. Select and prepare the sample collection point.**

- Complete a utility mark-out (PA One Call).
- Observe the condition of the building floor slab for apparent penetrations such as concrete floor cracks, floor drains, or sump holes.
- Note the floor conditions on the sampling form and select a potential location or locations for a temporary subsurface probe.
- The location or locations should be central to the building away from foundation walls and apparent penetrations for sub-slab or as closely as possible to the building foundation for near-slab
- Review the proposed location or locations with the occupant/owner describing how the sampling port or ports will be installed.
- Mark the proposed location(s) and describe the location(s) on the sampling form.
- Using the PID, screen indoor air around floor penetrations such as concrete floor cracks, floor drains, or sump holes. Record the indoor air PID readings on the sampling form.

#### **2. Installation of temporary subsurface sample point.**

- Record ambient air temperature and barometric pressure.
- Attach a decontaminated 5/8" steel drill bit to an electric hammer drill. Plug the drill into a drill interrupter box and test the interrupter box by touching a section of the drill bit to a piece of grounded metal. Drill a 5/8" hole into the slab at the pre-marked location to an approximate depth of 3" into the sub-slab material, to create an open cavity.
- Install a new silicone sleeve onto a decontaminated stainless-steel Vapor Pin®. Use a brush or vacuum to remove any loose dust/soil from the hole in the slab. Install the Vapor Pin® with silicone sleeve into the hole in the slab using a dead-blow hammer.



Confirm that the silicone sleeve forms a slight bulge between the slab and the shoulder of the Vapor Pin®. Place a new or decontaminated cap on top of the opening of the Vapor Pin®. Allow the sample port to sit for approximately two hours to allow the subsurface to return to equilibrium conditions.

- Check the condition of the sampling equipment:
- Confirm the flow controller vacuum gauge reads zero.
- Check the flow rate of the flow controller using an airflow meter. The flow rate should be approximately 12.5 mL/min for a 6L Summa canister being filled over a 8-hour period for primary samples or 25 mL/min for duplicate samples. Record the measured flow rate.
- Confirm the Summa canister valve is closed by tightening the knob clockwise.
- Unscrew the Summa canister cap. Check that the flow controller has O-rings intact.

### **3. During Sample Collection**

- Place SUMMA®-type canister adjacent to the temporary sampling port.
- Record SUMMA®-type canister serial number on sampling summary form and COC.
- Record sample identification on canister identification tag, and record on sampling summary form and COC.
- Remove brass plug from canister fitting.
- Install pressure gauge/metering valve on canister valve fitting and tighten. If pressure gauge has additional (2nd) fitting, install brass plug from canister fitting into gauge fitting and tighten.
- Open and close canister valve.
- Remove brass plug from gauge fitting and store for later use.
- Attach the flow controller to the Summa canister, making sure to tighten firmly.
- Remove the cap from the Vapor Pin® and record a PID measurement from the opening in the Vapor Pin®. Connect a stainless-steel Swagelok T-valve to the Vapor Pin® using new Teflon tubing. Connect new Teflon tubing to both outlets from the Swagelok T-valve. Attach one line of the Teflon tubing to the flow controller for the Summa canister (sample line) and then place a decontaminated shroud over the entire assembly and lead the other Teflon tubing line out of the shroud (purge line). Apply a ribbon of clay as a seal along the base of the shroud and at each location where tubing exits the shroud.
- Use helium as a tracer gas to verify there are no leaks in the Vapor Pin® sampling setup. Apply helium into the shroud until the atmosphere within the shroud is between 15-20% helium, as measured by a helium detector. Purge the Vapor Pin® using a vacuum pump and use a helium detector to determine the presence of helium in the purge line. If the helium concentration within the tubing is less than 10% of the concentration within the shroud atmosphere, the seal between the Vapor Pin® and slab is considered leak-tight. If a leak is detected, the Vapor Pin® will need to be reset and the helium leak check will need to be performed again.

- Attach a vacuum pump to the purge line used for the helium leak check. Purge approximately 3 to 5 sample line volumes prior to sampling to remove any introduced ambient air. The purge volume will be calculated using the following equation:
  - $\text{Purge volume} = 3.0\pi r^2 h$
  - r: inner radius of the sample point and sample tubing
  - h: length of the sub-slab soil gas sample point and sample tubing
- Close the Swagelok valve on the purge line and open it to the sample line. Open the Summa canister valve by turning the knob counter-clockwise until it is fully open.
- Observe the vacuum gauge and record the initial vacuum reading. The initial vacuum reading should be no less than -25 inches of Mercury ("Hg) and no more than -29.5" Hg.
- Record the sample start time, ambient air temperature and barometric pressure.
- Record date and local time (24-hour basis) of valve opening on sampling summary form and COC.
- Take digital photograph of SUMMA®-type canister and surrounding area.
- Collect the soil gas sample using the 6L Summa canister. Allow the Summa canister to fill until the end canister vacuum is -4" Hg (approximately 8 hours). If a duplicate sample is being collected, add a T fitting to the sample line to allow two Summa canisters to be filled simultaneously.
- At the end of the sampling duration, record the vacuum reading.
- Close the Summa canister by hand tightening the knob clockwise.
- Remove the flow controller and replace the Summa canister cap.

#### **4. Post Sample Collection**

- Revisit SUMMA®-type canister approximately at end of sample collection period (e.g., 8 hours after initiation of sample collection) and record gauge pressure on sampling form and COC.
- Record date and local time (24-hour basis) of valve closing on sampling form and COC.
- Close canister valve.
- Disconnect Teflon® tubing and remove pressure gauge / flow valve from canister.
- Reinstall brass plug on canister fitting and tighten.
- Remove SUMMA®-type canister from sample collection area.
- Disconnect the tubing line from the Vapor Pin® and remove the Vapor Pin® from the slab.
- Patch the hole in the slab using an appropriate concrete patching compound and return the work area to its original condition.
- Ensure the following information is recorded in a field book:

- Site and property information
- Summa canister #
- Flow controller #
- Measured flow rate
- Sample start date
- Sample start time
- Start Summa canister vacuum reading
- Start barometric pressure and air temperature
- Sample end date
- Sample end time
- End Summa canister vacuum reading
- End barometric pressure and air temperature
- Detailed sketch of sample location
- Ensure the label tag on the Summa canister is complete.
- Relinquish the sample Summa canister and any accompanying duplicates and field blanks under chain-of-custody to the laboratory for analysis.

**Area 2:** Air sample obtained from crawl space or basement without an apparent vapor barrier.

#### **1. Select and prepare the sample collection point**

- Observe the area for the apparent presence of items or materials that may potentially produce or emit VOCs and interfere with analytical laboratory analysis of the collected sample. Record relevant information on Building Inventory Form and document with digital photographs.
- Using the PID, screen indoor air in the location intended for sampling and near potential VOC sources (i.e. paints, glues, household cleaners, dry cleaned clothes, etc.) to assess the potential gross presence of VOCs. Record PID readings on the sampling form. Items or materials exhibiting PID readings shall be considered probable sources of VOCs and, given approval of the owner or occupant, will be removed prior to sampling. If practical, sampling will be rescheduled for 24-hours later.

## **2. Preparation of 8-Hour SUMMA®-type canister and collection of sample**

- Place SUMMA®-type canister at breathing zone height (approximately 3 to 5 ft. above basement floor or about 1 ft. above floor of crawl space). Canister can be placed on a stable surface, such as a table or bookshelf, or affixing to a wall or ceiling support with nylon rope. Avoid placing canisters near windows or other potential sources of drafts and air supply vents.
- Record SUMMA®-type canister serial number on sampling summary form and COC.
- Record sample identification on canister identification tag, and record on sampling summary form and COC.
- Remove brass plug from canister fitting.
- Install pressure gauge / metering valve on canister valve fitting and tighten. If pressure gauge has additional (2nd) fitting, install brass plug from canister fitting into gauge fitting and tighten.
- Open and close canister valve.
- Record gauge pressure on sample summary form and COC. Gauge pressure must read >25 inches Hg. Replace SUMMA®-type canister if gauge pressure reads <25 inches Hg.
- Remove brass plug from gauge fitting and store for later use.
- Open canister valve to initiate sample collection.
- Record date and local time (24-hour basis) of valve opening on sampling summary form and COC.
- Take digital photograph of SUMMA®-type canister and surrounding area.

## **3. Termination of 8-hour sample collection**

- Revisit SUMMA®-type canister approximately at end of sample collection period (e.g., 8 hours after initiation of sample collection) and record gauge pressure on sampling form and COC.
- Record date and local time (24-hour basis) of valve closing on sampling form and COC.
- Close canister valve.
- Remove pressure gauge / flow valve from canister.
- Reinstall brass plug on canister fitting and tighten.
- Remove SUMMA®-type canister from sample collection area.

## **4. Preparation and shipment of sample to analytical laboratory**

- Pack SUMMA<sup>®</sup>-type canister in shipping container, note presence of brass plug installed in tank fitting.
- Complete COC and place requisite copies in shipping container.
- Close shipping container and affix custody seal to container closure.

#### **Quality Assurance/Quality Control (QA/QC) samples:**

The collection of QA/QC samples will include the submittal of blind sample duplicates to the analytical laboratory for analyses of target compounds. Area 2- type duplicate samples will be collected "side-by-side" over the same time interval. Area 1- type duplicate samples will be obtained using a stainless steel "tee" type fitting and 1/4-inch O.D. Teflon<sup>®</sup>- tubing connected to the same subsurface probe.

### **3.2 Substructure Soil Vapor Grab Sampling**

Substructure soil vapor grab samples will be collected from beneath residential, commercial, industrial, institutional, and multiuse buildings with an apparent vapor barrier using SUMMA<sup>®</sup> type air canisters equipped with metering flow controllers. This technique is intended for 20-minute sample collection. Substructure soil vapor grab samples may be collected from a temporary installed sampling port through an apparent vapor barrier (such as floor slab or plastic liner).

#### **Substructure soil vapor grab sampling will require the following equipment:**

- 1.4-liter, stainless steel, pre-evacuated SUMMA<sup>®</sup> canister - laboratory provided
- Pressure gauge with integrated 20-minute metering valve - laboratory provided
- PID
- Utility Knife
- Electric hammer drill with 3/8-inch diameter drill bit
- Two 50-ft long electrical extension cords
- 1/4-inch O.D. Teflon<sup>®</sup> tubing
- 1/4-inch stainless steel valve and stainless steel "tee" type fitting
- 3/16-inch I.D. silastic tubing
- 60 cc polyethylene syringe for purging tubing
- Quick-drying hydraulic cement

- Wristwatch
- Flashlight
- Dust pan and broom
- COC form - laboratory provided

### **Procedure for 20-Minute Substructure Soil Vapor Grab Sample Collection**

Survey the lowest accessible portion of the building (e.g., crawl space, basement, or first floor of slab-on-grade construction) will be observed to assess applicability of sampling technique (i.e., Is there a vapor barrier?). The steps provided below should be considered a general guidance on the collection of substructure soil vapor samples; the sequence can be modified as needed based on site- or project-specific conditions at the time of sample collection.

#### **Selection and preparation of sample collection point**

- Observe the condition of the building floor slab for apparent penetrations such as concrete floor cracks, floor drains, or sump holes. Note the floor conditions on the sampling form and select a potential location or locations for a temporary subsurface probe. The location or locations should be central to the building away from foundation walls and apparent penetrations. Review the proposed location or locations with the occupant/owner describing how the sampling port or ports will be installed. Mark the proposed location(s) and describe the location(s) on the sampling form.
- Using the PID, screen indoor air around floor penetrations such as concrete floor cracks, floor drains, or sump holes. Record the indoor air PID readings on the sampling form.

#### **Installation of temporary subsurface sample point**

- Drill a 3/8-inch diameter hole through the thickness of the slab. Extend the hold about two inches into the sub-slab material using either the drill bit or a steel probe rod.
- Insert a section of 1/4-inch O.D. Teflon<sup>®</sup> tubing to the bottom of the floor slab. Seal the annular space between the 3/8-inch hole and 1/4-inch tubing with either a beeswax seal, or with an approved putty/seal (i.e. non-VOC emitting play dough). The beeswax will be melted with an electric hot plate.
- Connect the 1/4-inch Teflon<sup>®</sup> tubing to a stainless-steel valve using 3/16-inch ID silastic tubing. Open the in-line valve and purge the probe tubing using a polyethylene 60 cc syringe (purging with a PID is also acceptable if no indoor air samples are to be collected). Close the valve, remove and cap the syringe, and connect the silastic tubing to the in-line valve on the SUMMA<sup>®</sup> canister. The air/soil vapor syringe will be discharge out of doors if indoor air samples are to be collected. For duplicate sample locations connect a second canister before purging by installing a 1/4-inch stainless steel "tee" fitting between the probe discharge tubing and the stainless-steel valve.

### **Preparation of 20-minute SUMMA® canister and collection of sample**

- A. Place SUMMA® canister adjacent to the temporary sampling port.
- B. Record SUMMA® canister serial number on sampling summary form and COC.
- C. Record sample identification on canister identification tag, and record on sampling summary form and COC.
- D. Remove plastic cap canister fitting.
- E. Open and close canister valve.
- F. Record gauge pressure on sample summary form and COC. Gauge pressure must read >25 inches Hg. Replace SUMMA® canister if gauge pressure reads <25 inches Hg.
- G. Connect canister to silastic tubing already connected to the subsurface probe.
- H. Open canister valve and in-line stainless steel valve to initiate sample collection.
- I. Record date and local time (20-minute basis) of valve opening on sampling summary form and COC.
- J. Take digital photograph of SUMMA® canister and surrounding area.

### **Termination of 20-minute sample collection**

- A. Upon completion of 20-minute sample collection, record gauge pressure on sampling form and COC.
- B. Record date and local time (20-minute basis) of valve closing on sampling form and COC.
- C. Close canister valve.
- D. Disconnect silastic tubing and recap pressure gauge.
- E. Remove SUMMA® canister from sample collection area.
- F. Remove temporary probe from hole. Fill hole with a quick drying hydraulic cement. Finish flush with floor surface.

### **3.3 Indoor Air Sampling**

Indoor air samples will be collected from residential, commercial, industrial, institutional, and multiuse buildings. This technique is intended to be a general directive for the collection of indoor air samples using SUMMA®-type air canisters equipped with metering flow controllers for collecting a "time-averaged" indoor air sample. This procedure is intended for 24-hour sample collection and may be collected in conjunction with 24-hour substructure soil vapor sampling. Indoor air data will be recorded on a field data record.



For the purposes of evaluating the potential vapor migration from soils and groundwater into indoor air, samples will be collected from the lowest usable area of the building. Indoor air samples may be collected from one of the following areas:

1. Unfinished basement or unfinished first floor of slab-on-grade building;
2. Finished basement or finished first floor of slab-on-grade building; or
3. First floor living area above a dirt-floored crawl space or unfinished basement.

**Indoor air sampling will require the following equipment:**

- 6-liter, stainless steel, pre-evacuated SUMMA<sup>®</sup>-type canister - laboratory provided
- Pressure gauge with integrated 24-hour metering valve - laboratory provided
- Two, 9/16-inch, open-end wrenches
- PID – part per billion range detector for screening indoor air
- Wristwatch
- COC form -laboratory provided

**Procedure for Indoor Air Sample Collection**

The following section provides a general guidance on the collection of indoor air samples; the sequence can be modified as needed based on site specific conditions at the time of sample collection.

**Selection and Preparation of indoor air sample collection area**

- A. Conduct interview with occupant/owner. Complete Indoor Air Quality Questionnaire and Building Inventory Form (Appendix A).
- B. Observe the area for the apparent presence of items or materials that may potentially produce or emit VOCs and interfere with analytical laboratory analysis of the collected sample. Record relevant information on Building Inventory Form and document with digital photographs.
- C. Using the PID, screen indoor air in the location intended for sampling and near potential VOC sources (i.e. paints, glues, household cleaners, dry cleaned clothes, etc.) to assess the potential gross presence of VOCs. Record PID readings on the sampling form. Items or materials exhibiting PID readings shall be considered probable sources of VOCs and, given approval of the owner or occupant, will be removed prior to sampling. If practical, sampling will be rescheduled for 24-hours later.

### **Preparation of SUMMA®-type canister and collection of indoor air sample**

- A. Place SUMMA®-type canister at breathing zone height (approximately 3 to 5 ft. above floor). Canister can be placed on a stable surface, such as a table or bookshelf, or affixing to a wall or ceiling support with nylon rope. Avoid placing canisters near windows or other potential sources of drafts and air supply vents.
- B. Record SUMMA®-type canister serial number on sampling summary form and COC.
- C. Record sample identification on canister identification tag, and record on sampling summary form and COC.
- D. Remove brass plug from canister fitting.
- E. Install pressure gauge / metering valve on canister valve fitting and tighten. If pressure gauge has additional (2nd) fitting, install brass plug from canister fitting into gauge fitting and tighten.
- F. Open and close canister valve.
- G. Record gauge pressure on sample summary form and COC. Gauge pressure must read >25 inches Hg. Replace SUMMA®-type canister if gauge pressure reads <25 inches Hg.
- H. Remove brass plug from gauge fitting and store for later use.
- I. Open canister valve to initiate sample collection.
- J. Record date and local time (24-hour basis) of valve opening on sampling summary form and COC.
- K. Take digital photograph of SUMMA®-type canister and surrounding area.

### **Termination of indoor air sample collection**

- A. Revisit SUMMA®-type canister approximately at end of sample collection period (e.g., 24 hours after initiation of sample collection) and record gauge pressure on sampling form and COC.
- B. Record date and local time (24-hour basis) of valve closing on sampling form and COC.
- C. Close canister valve.
- D. Remove pressure gauge / flow valve from canister.
- E. Reinstall brass plug on canister fitting and tighten.
- F. Remove SUMMA®-type canister from sample collection area.

### **Preparation and shipment of sample to analytical laboratory**

- A. Pack SUMMA®-type canister in shipping container, note presence of brass plug installed in tank fitting.
- B. Complete COC and place requisite copies in shipping container.
- C. Close shipping container and affix custody seal to container closure.

**Quality Assurance/Quality Control (QA/QC) samples:**

The collection of QA/QC samples will include the submittal of blind sample duplicates to the analytical laboratory for analyses of target compounds. Duplicate samples will be collected "side-by-side" over the same time interval.

**3.4 Ambient Air Sampling**

Ambient (outdoor) air samples will be collected near residential, commercial, industrial, institutional, and multiuse buildings. This technique is intended to be a general directive for the collection of ambient air samples using SUMMA<sup>®</sup>-type air canisters equipped with metering flow controllers for collecting a "time-averaged" ambient air sample. This procedure is intended for 24-hour sample collection. Ambient air sampling information will be recorded on the FDR.

**Ambient air sampling will require the following equipment:**

- 6-liter, stainless steel, pre-evacuated SUMMA<sup>®</sup>-type canister - laboratory provided
- Pressure gauge with integrated 24-hour metering valve - laboratory provided
- Two, 9/16-inch, open-end wrenches
- PID – part per billion range detector for screening air
- Wristwatch
- Indoor Air Quality Questionnaire and Building Inventory Form (Appendix A)
- COC form - laboratory provided

## **Procedure for Ambient (outdoor) Air Sample Collection**

The following section provides a general guidance on the collection of ambient air samples; the sequence can be modified as needed based on site specific conditions at the time of sample collection.

### **Selection and Preparation of ambient sample collection area**

- A. Choose an area for sample collection that is upwind of the property (properties) being assessed, if possible. Collect sample away from wind breaks, if possible.
- B. Observe the area for the apparent presence of items or materials that may potentially produce or emit VOCs and interfere with analytical laboratory analysis of the collected sample (i.e. fuel tanks, gasoline, paint storage, etc.). Record relevant information on Building Inventory Form and document with digital photographs.
- C. Using the PID, screen ambient air in the location intended for sampling to assess the potential gross presence of VOCs. Record PID readings on the sampling form.

### **Preparation of SUMMA<sup>®</sup> canister and collection of ambient sample**

- A. Place SUMMA<sup>®</sup>-type canister approximately 5 ft. above ground (or equivalent to the mid-point of the ground story of the building(s)). Canister can be placed on a stable surface, or suspended from structure with nylon rope.
- B. Record SUMMA<sup>®</sup>-type canister serial number on sampling summary form and COC.
- C. Record sample identification on canister identification tag, and record on sampling summary form and COC.
- D. Remove brass plug from canister fitting.
- E. Install pressure gauge/metering valve on canister valve fitting and tighten. If pressure gauge has additional (2nd) fitting, install brass plug from canister fitting into gauge fitting and tighten.
- F. Open and close canister valve.
- G. Record gauge pressure on sample summary form and COC. Gauge pressure must read >25 inches Hg. Replace SUMMA<sup>®</sup>-type canister if gauge pressure reads <25 inches Hg.
- H. Remove brass plug from gauge fitting and store for later use.
- I. Open canister valve to initiate sample collection.
- J. Record date and local time (24-hour basis) of valve opening on sampling summary form and COC.
- K. Take digital photograph of SUMMA<sup>®</sup>-type canister and surrounding area.

### **Termination of ambient sample collection**

- A. Revisit SUMMA®-type canister approximately at end of sample collection period (e.g., 24 hours after initiation of sample collection) and record gauge pressure on sampling form and COC.
- B. Record date and local time (24-hour basis) of valve closing on sampling form and COC.
- C. Close canister valve.
- D. Remove pressure gauge / flow valve from canister.
- E. Reinstall brass plug on canister fitting and tighten.
- F. Remove SUMMA®-type canister from sample collection area.

### **Preparation and shipment of sample to analytical laboratory**

- A. Pack SUMMA®-type canister in shipping container, note presence of brass plug installed in tank fitting.
- B. Complete COC and place requisite copies in shipping container.
- C. Close shipping container and affix custody seal to container closure.

### **Quality Assurance/Quality Control (QA/QC) samples:**

The collection of QA/QC samples will include the submittal of blind sample duplicates to the analytical laboratory for analyses of target compounds. Duplicate samples will be collected "side-by-side" over the same time interval.

## **3.5 Direct Push (GeoProbe®) Deep and Shallow Soil Vapor Sampling**

Soil vapor grab samples will be collected from shallow (3 to 5 feet below ground surface (bgs) or shallower located under parking lot pavement) and deep (15 to 25 feet bgs) locations at predetermined locations across the site. Permanent or semi-permanent sampling points will be installed, allowed to equilibrate over a 24-hour period, and sampled using SUMMA® type air canisters equipped with metering flow controllers. This technique is intended for 15-minute sample collection.

### **Direct Push (GeoProbe®) deep soil vapor grab sampling will require the following equipment:**

- GeoProbe® soil vapor implant installation equipment – subcontractor provided
- 1.4-liter, stainless steel, pre-evacuated SUMMA® canister - laboratory provided
- Pressure gauge with integrated 100 cc/minute (15-minute) metering valve - laboratory provided
- ¼-inch outside diameter, six-inch-long soil vapor implants

- Hand auger
- Glass beads – 60 to 100 mesh
- Bentonite chips -16 mesh
- funnel
- PID
- Utility Knife
- ¼-inch O.D. Teflon® tubing
- ¼-inch stainless steel valve and stainless steel "tee" type fitting
- 3/16-inch I.D. silastic tubing
- 60 cc polyethylene syringe for purging tubing
- Wristwatch
- COC form - laboratory provided

### **Procedure for Direct Push (GeoProbe®) Deep Soil Vapor Grab Sample Collection**

Survey the known site characteristics including source areas, groundwater data, utility trench locations, groundwater flow, and potentially impacted areas to assess applicability of sampling technique. The steps provided below should be considered a general guidance on the collection of deep soil vapor samples; the sequence can be modified as needed based on site- or project-specific conditions at the time of sample collection.

### **Selection and preparation of sample collection point**

- A. Identify utilities prior to the selection of deep soil vapor sample locations.
- B. Assess utility clearance at all locations. Review the proposed location or locations with the site representative.
- C. Mark the proposed location(s) and describe the location(s) on the sampling form.

### **Installation of deep soil vapor sample point**

- A. Collect continuous soil samples using direct push technology to characterize subsurface soils. Soil characteristics (such as soil type, moisture, color) and photoionization detector (PPB-Rae) field screening results will be recorded on a field data record. PID screening, as well as soil characteristics will be used to select vapor implant depths. Consideration will be given to more permeable soils encountered during sampling. The

PID will be calibrated to a 10 parts per million isobutylene standard and set point of 1.0.

- B. Soil vapor implants will be installed by either lowering the implant down the direct push rods to the desired depth, or attaching the implant to a GeoProbe® implant Anchor/Drive point (GeoProbe® PR-14) prior to driving the rods to the desired depth.
- C. Attach quarter-inch outside diameter Teflon tubing to the soil vapor implant allowing approximately two feet to extend above the ground surface and be sealed at the surface with a plastic cap.
- D. Using the funnel, pour a sufficient volume of glass beads down the rods to fill the space around the implant.
- E. Using the funnel, pour a sufficient volume of bentonite chips to create an approximate two-foot bentonite seal above the glass beads.
- F. Retract the rods prior to hydrating the bentonite.
- G. Pour a sufficient volume of ASTM Type II water down the direct push hole to hydrate the volume of bentonite chips installed.
- H. Use native backfill, or a cement/bentonite grout mixture to backfill the boring to the ground surface.
- I. If shallow and deep implants are to be installed at one location, both implants can be placed within the same boring. The upper implant will be surrounded by glass beads and a bentonite seal will be installed both below and above the glass beads.
- J. Complete a Soil Vapor Probe Construction Diagram for each sample location and record field data and observations on the GeoProbe® Soil Vapor Sampling Record.

#### **Installation of shallow soil vapor sample point**

- A. Collect continuous soil samples using direct push technology to characterize subsurface soils. Soil characteristics (such as soil type, moisture, color) and photoionization detector (PPB-Rae) field screening results will be recorded on a field data record. PID screening, as well as soil characteristics will be used to select vapor implant depths. Consideration will be given to more permeable soils encountered during sampling. The PID will be calibrated to a 10 parts per million isobutylene standard and set point of 1.0.
- B. Soil vapor implants will be installed by either lowering the implant down the direct push rods to the desired depth, or attaching the implant to a GeoProbe® implant Anchor/Drive point (GeoProbe® PR-14) prior to driving the rods to the desired depth.
- C. Attach quarter-inch outside diameter Teflon tubing to the soil vapor implant allowing approximately two feet to extend above the ground surface and be sealed at the surface with a plastic cap.
- D. Using the funnel, pour a sufficient volume of glass beads down the rods to fill the space around the implant.
- E. Using the funnel, pour a sufficient volume of bentonite chips to create an approximate two-foot bentonite seal above the glass beads.
- F. Retract the rods prior to hydrating the bentonite.
- G. Pour a sufficient volume of ASTM Type II water down the direct push hole to hydrate the volume of bentonite chips installed.



- H. Use native backfill, or a cement/bentonite grout mixture to backfill the boring to the ground surface.
- I. If shallow and deep implants are to be installed at one location, both implants can be placed within the same boring. The upper implant will be surrounded by glass beads and a bentonite seal will be installed both below and above the glass beads.
- J. Complete a Soil Vapor Probe Construction Diagram for each sample location and record field data and observations on the GeoProbe® Soil Vapor Sampling Record.

#### **Preparation of 20-minute SUMMA® canister and collection of sample**

- K. Place SUMMA® canister adjacent to the temporary sampling port.
- L. Record SUMMA® canister serial number on sampling summary form and COC.
- M. Record sample identification on canister identification tag, and record on sampling summary form and COC.
- N. Remove plastic cap canister fitting.
- O. Open and close canister valve.
- P. Record gauge pressure on sample summary form and COC. Gauge pressure must read >25 inches Hg. Replace SUMMA® canister if gauge pressure reads <25 inches Hg.
- Q. Connect canister to silastic tubing already connected to the subsurface probe.
- R. Open canister valve and in-line stainless steel valve to initiate sample collection.
- S. Record date and local time (20-minute basis) of valve opening on sampling summary form and COC.
- T. Take digital photograph of SUMMA® canister and surrounding area.

#### **Termination of 20-minute sample collection**

- G. Upon completion of 20-minute sample collection, record gauge pressure on sampling form and COC.
- H. Record date and local time (20-minute basis) of valve closing on sampling form and COC.
- I. Close canister valve.
- J. Disconnect silastic tubing and recap pressure gauge.
- K. Remove SUMMA® canister from sample collection area.
- L. Remove temporary probe from hole. Fill hole with a quick drying hydraulic cement. Finish flush with floor surface.

#### **4.0 REFERENCES**

NHDES, 2006. "Vapor Intrusion Guidance"; New Hampshire Department of Environmental Services; Site Remediation Programs, Waste Management Division; July 2006.

USEPA, 2001. "Standard Operating Procedure – Soil Gas Sampling", ERT SOP #2042, Rev. 1.0, 4/18/01 - Attached



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 1 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

### CONTENTS

- 1.0 SCOPE AND APPLICATION\*
- 2.0 METHOD SUMMARY\*
- 3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE
  - 3.1 Tedlar Bags
  - 3.2 Sorbent Tubes\*
  - 3.3 Summa Canisters
- 4.0 INTERFERENCES AND POTENTIAL PROBLEMS
  - 4.1 PID Measurements\*
  - 4.2 FID Measurements\*
  - 4.3 Factors Affecting the Concentrations of Organic Compounds in Soil Gas\*
  - 4.4 Soil Probe Clogging\*
  - 4.5 Underground Utilities
- 5.0 EQUIPMENT/APPARATUS
  - 5.1 Slam Bar Method
  - 5.2 Power Hammer Method
  - 5.3 Direct-Push (Geoprobe) Method
- 6.0 REAGENTS
- 7.0 PROCEDURES
  - 7.1 Soil Gas Probe Installation\*
    - 7.1.1 Slam Bar Method
    - 7.1.2 Power Hammer Method
    - 7.1.3 Direct-Push Method
  - 7.2 Screening with Field Instruments\*
  - 7.3 Tedlar Bag Sampling\*
  - 7.4 Sorbent Tube Sampling
    - 7.4.1 Additional Apparatus\*
    - 7.4.2 Sample Collection\*
  - 7.5 Summa Canister Sampling\*
- 8.0 CALCULATIONS
  - 8.1 Field Screening Instruments
  - 8.2 Field Portable GC Analysis



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 2 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

### CONTENTS (cont'd)

#### 9.0 QUALITY ASSURANCE/QUALITY CONTROL

- 9.1 Sample Sorbent Tubes\*
- 9.2 Sample Probe Contamination\*
- 9.3 Sample Train Contamination\*
- 9.4 FID/PID Calibration\*
- 9.5 Trip Blanks\*
  - 9.5.1 Tedlar Bags
  - 9.5.2 Sorbent Tubes
  - 9.5.3 Summa Canisters
- 9.6 Field Blanks\*
  - 9.6.1 Tedlar Bags
  - 9.6.2 Sorbent Tubes
- 9.7 Trip Standards
- 9.8 Lot Blanks\*
  - 9.8.1 Tedlar Bags\*
  - 9.8.2 Summa Canister Check\*
  - 9.8.3 Sorbent Tubes\*
- 9.9 Options
  - 9.9.1 Duplicate Samples\*
  - 9.9.2 Spikes

#### 10.0 DATA VALIDATION

- 10.1 Blanks\*

#### 11.0 HEALTH AND SAFETY\*

#### 12.0 REFERENCES\*

#### 13.0 APPENDICES\*

- A. Figures
- B. HNu Field Procedure

\* These sections are affected by Revision 0.0



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 3 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

### 1.0 SCOPE AND APPLICATION

Soil gas monitoring provides a quick means of detecting volatile organic compounds (VOCs) in the soil subsurface. Using this method, underground VOC contamination can be identified, and the source, extent, and movement of pollutants can be traced.

This standard operating procedure (SOP) outlines the methods used for the installation of soil gas wells; the collection of soil gas using Tedlar bags, sorbent tubes, and/or Summa canisters; and measurement of organic vapor levels in the soil gas using a Photo Ionization Detector (PID), Flame Ionization Detector (FID) and/or other air monitoring devices.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on-site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

### 2.0 METHOD SUMMARY

A 4-inch (") diameter hole is driven into the ground using manual (i.e., slam bar) or power driven mechanical (i.e., Geoprobe) methods. Soil gas can be sampled at specific depths by controlled penetration and/or the use of a longer bar or bar attachments. A 1/4" outer diameter (O.D.) stainless steel probe is inserted into the hole. The hole is sealed around the top of the probe using clean modeling clay. The gas contained in the interstitial spaces of the soil is pulled through the probe using an air sampling pump. The sample may be stored in Tedlar bags, drawn through sorbent cartridges, or analyzed directly using a field portable instrument such as a PID. An air sampling pump is not used for Summa canister sampling of soil gas; sampling is achieved by soil gas equilibration with the evacuated Summa canister.

Power driven mechanical devices may be used to make holes when conditions make the use of manual devices unfeasible (i.e., frozen ground, very dense clays, pavement, etc.). Commercially available soil gas sampling probes (hollow, 1/2" O.D. steel probes) can be driven to the desired depth using a power hammer (e.g., demolition hammer or Geoprobe). Soil gas samples can be drawn through the probe itself, or through Teflon tubing inserted through the probe and attached to the probe point. Samples are collected and analyzed as described below.

Other field air monitoring devices, such as the Combustible Gas Indicator (CGI) and the Organic Vapor Analyzer (OVA), can also be used, depending on specific site conditions. Measurement of soil temperature using a temperature probe may also be desirable. Bagged samples may be analyzed in a field laboratory using portable gas chromatography (GC) instrumentation, or shipped to a laboratory using an overnight service.

### 3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

#### 3.1 Tedlar Bags

Soil gas samples are generally collected in 1.0-liter (L) Tedlar bags. Bagged samples should be stored in the dark (i.e., in opaque containers) and protected from mechanical damage during transit



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 4 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

to the laboratory. Further, bagged samples should be maintained at ambient temperature by placing them in coolers and out of direct sunlight. Samples should be analyzed as soon as possible, preferably within 24 to 48 hours following sample collection. Refer to ERT/SERAS SOP# 2102, *Tedlar Bag Sampling*, for additional information.

### 3.2 Sorbent Tubes

Soil gas can be drawn directly onto sorbent tubes (i.e., Tenax tubes) and analyzed by Gas Chromatography/Mass Spectrometer (GC/MS) methodologies. Bagged samples can also be drawn onto tubes. If sorbent tubes are to be used, special care must be taken to avoid contamination. Refer to ERT/SERAS SOP# 2104, *Tenax/CMS Tube Sampling*, for additional information. Samples should be refrigerated at 4 °C during storage and analyzed within 30 days of collection. Samples taken on multi-sorbent tubes should be analyzed as soon as possible after sampling.

### 3.3 Summa Canisters

The Summa canisters used for soil gas sampling have a 6-L sample capacity and are certified clean by GC/MS analysis before being used in the field. After sampling is completed, they are stored and shipped in travel cases. Most volatile organic compounds (VOCs) can be recovered from canisters with minimal loss up to thirty days. Refer to ERT/SERAS SOP# 1704, *Summa Canister Sampling*, for additional information.

## 4.0 INTERFERENCES AND POTENTIAL PROBLEMS

### 4.1 PID Measurements

Several factors specific to soil gas can affect the response of a PID (e.g., HNu PI 101). High humidity can cause lamp fogging and decreased sensitivity. This can occur when soil moisture levels are high, or when a soil gas probe is in the saturated zone. High concentrations of methane can cause a downscale deflection of the meter. High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpene hydrocarbons in wooded areas, will affect instrument response. Refer to ERT/SERAS SOP# 2114, *Photoionization Detector (PID) HNu* for additional information.

### 4.2 FID Measurements

Several factors specific to soil gas can affect the response of an FID (e.g., OVA Model 128). High humidity can cause the FID to flame out or not ignite at all. This can be significant when soil moisture levels are high, or when a soil gas probe is in the saturated zone. The FID can only read organic based compounds (they must contain carbon in the molecular structure). The FID also responds poorly to hydrocarbons and halogenated hydrocarbons (such as gasoline, propane fuel). High and low temperature, electrical fields and FM radio transmission will also affect instrument response. Consult the instrument manual for additional information.

### 4.3 Factors Affecting the Concentrations of Organic Compounds in Soil Gas

Concentrations of organic compounds in soil gas can be affected by the physical and chemical characteristics of the soil and by soil moisture. Organic molecules can be tightly adsorbed to the



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 5 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

surface of chemically active soil particles, such as clays, thus reducing the concentration in the soil interstitial spaces. Similarly, some organic compounds can be dissolved in the soil water or associated with soil organic components (i.e., humic acids).

Soil porosity and permeability will affect the movement of soil gas and the recharge rate of the soil gas well. The movement of organic vapors through fine textured soil may be very slow, thus limiting the sample volume available and the use of this technique. Existing information and soil surveys prepared by the Soil Conservation Service should be consulted prior to planning and designing a soil gas survey.

The presence of a high, or perched water table, or of an impermeable underlying layer (such as a clay lens or layer of buried slag) may interfere with the movement and sampling of the soil gas. Knowledge of site geology is useful in such situations, and can prevent inaccurate sampling.

### 4.4 Soil Probe Clogging

A common problem with the soil gas sampling is clogging of the probe. A clogged probe can be identified by using an in-line vacuum gauge or by listening for the sound of the pump laboring. This problem can usually be eliminated by using a wire cable to clear the probe (see Section 7.1.3.).

### 4.5 Underground Utilities

Prior to selecting sample locations, an underground utility search must be completed. The local utility companies can be contacted and requested to mark the locations of their underground lines. Each sample location should also be screened with a metal detector or magnetometer to verify that no underground metallic or ferro-magnetic pipes or drums are present.

## 5.0 EQUIPMENT/APPARATUS

### 5.1 Slam Bar Method

- Slam bar
- Soil gas probes: stainless steel tubing, 1/4" O.D., 5-foot (ft) length
- Flexible wire or cable
- "Quick Connect" fittings
- Modeling clay.
- Vacuum box
- Pumps, capable of drawing approximately 3.0 L/min
- 1/4" Teflon tubing, 2-ft to 3-ft lengths
- 1/4" Tygon tubing
- Tedlar bags, 1.0-L
- Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)
- PID/FID, or other field air monitoring devices
- Cooler(s)
- Metal detector or magnetometer
- Portable GC instrument
- Summa canisters (plus shipping cases)



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 6 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

Large dark plastic bags

### 5.2 Power Hammer Method

Power (Demolition) hammer  
½" O.D. steel probes, extensions, and points  
Dedicated aluminum sampling points  
¼" Teflon tubing, 2-ft to 3-ft lengths  
"Quick Connect" fittings  
Modeling clay.  
Vacuum box  
Pumps, capable of drawing approximately 3.0 L/min  
¼" Tygon tubing  
Tedlar bags, 1.0-L  
Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)  
PID/FID or other field air monitoring devices  
Cooler(s)  
Metal detector or magnetometer  
Portable GC instrument  
Summa canisters (plus shipping cases)  
Generator w/extension cords.  
High lift jack assembly  
Large dark plastic bags

### 5.3 Direct-Push (Geoprobe ) Method

Tubing; polyethylene, Teflon, or stainless steel  
Gas sampling cap  
probe rods  
Tubing adaptor(s)  
Expendable point holder, threaded  
Expendable drive point(s)  
O-rings for expendable point holder  
O-rings for adaptor  
O-rings for probe rods  
O-rings for gas sampling cap  
Vacuum pumps  
Tape  
Tedlar bags, 1.0-L  
Summa canisters (plus shipping cases)  
Sample documentation (soil gas labels, field data sheets, logbook, etc.)  
Metal detector or magnetometer  
Cooler(s)  
Large dark plastic bags  
Portable GC instrument

### 6.0 REAGENTS





# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 7 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

Calibration and spike gases  
Deionized, organic-free water  
Methanol, High Performance Liquid Chromatography (HPLC) grade  
Ultra-zero grade compressed air  
Propane torch

### 7.0 PROCEDURES

#### 7.1 Soil Gas Probe Installation

##### 7.1.1 Slam Bar Method

1. A hole slightly deeper than the desired sampling depth is made. For sampling up to 5 feet, a 5-ft single piston slam bar is used. For deeper depths, a piston slam bar with threaded 4-ft-long extensions is used.
2. The tip of the rod is placed on the ground and the piston of the slam bar is used to drive the rod to the desired depth. The number of blows required to reach the desired depth is recorded.
3. After the hole is made, the slam bar is carefully withdrawn to prevent the collapse of the walls.
4. The soil gas probe is carefully inserted into the hole. To prevent plugging of the probe, a decontaminated metal wire or cable, slightly longer than the probe and with an O.D. slightly less than the inner diameter (I.D.) of the rod, is inserted in the probe rod; 1- to 2-inches of wire should protrude from the end of the probe. The probe is inserted to full depth of the hole, then pulled up three to six inches. The probe is cleared by moving the cable up and down several times.
5. The top of the sample hole is sealed at the surface to prevent infiltration of ambient air. A golf-ball size lump of clean modeling clay is kneaded until it becomes soft. The clay is carefully molded around the probe at the soil surface to seal the space between the probe and the hole.
6. If semi-permanent soil gas installations are required, the probe remains in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

##### 7.1.2 Power Hammer Method

1. A power hammer may be used to make holes when the soil is very hard, frozen or fine textured (clay), or when soil gas from beneath pavement or concrete is collected.
2. A power hammer is used to drive the probe to the desired depth (up to 12 feet may be attained with extensions). Threaded extensions are added until the desired depth is needed.
3. After the hole is made, the threaded rod is carefully withdrawn. This should be done



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 8 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

in such a manner to prevent collapse of the walls. If necessary, a jack assembly may be used to retrieve the rods.

4. The soil gas probe is installed in the hole as described in Section 7.1.1, Steps 4 and 5.
5. If semi-permanent soil gas installations are required, the probe remains in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

### 7.1.3 Direct-Push Method

1. Direct-push sampling technology refers to soil gas samplers that are inserted into the ground without the use of slam bars, demolition hammers, or drilling rigs. The U.S. EPA/ERT utilizes a Direct-Push unit mounted on an all-terrain track mounted vehicle, and direct push tools. These tools are able to collect samples at depths greater than 50 feet, depending on soil conditions.
2. Sampling probes, consisting of 3-foot sections of flush-threaded, 1¼-inch hardened steel alloy steel rod tipped by an expendable steel point, are driven into the ground to the target depth. The probe tools are withdrawn to release the expendable tip and allow soil gas to flow into the tool's tubing.
3. To ensure a representative soil gas sample, a discrete volume of gas is purged to rid the tubing of atmospheric air and allow the subsurface soil gas to enter the probe tubing. The volume of gas removed is determined by the volume of tubing employed in the probe. (Unlike groundwater sampling, purging of a soil gas probe is designed to remove only the ambient air within the tubing.)
4. After allowing the system to return to atmospheric pressure, an aliquot of soil gas is withdrawn from the probe. Duplicate samples are collected as necessary and required.
5. If semi-permanent soil gas installations are required, the probe remains in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

### 7.2 Screening with Field Instruments

1. It is recommended that any appropriate SOPs and the manufacturers' manuals be consulted for the correct use and calibration of all instrumentation. Pumps should be calibrated prior to use in the field.
2. An amount of air, equivalent to the volume of the soil gas well must be calculated prior to sampling. Connect a vacuum pump to the sample probe using a section of Teflon tubing. The pump is turned on and adjusted to a flow rate of 3.0 L/minute. The calculated volume of air is evacuated from the hole by pulling a vacuum through the probe for the specified length of time. Longer time is required for sample wells of greater depths.
3. After evacuation, a monitoring instrument (i.e. HNu or OVA) is connected to the probe using a Teflon connector. Upon stabilization, the reading is recorded on soil gas data sheets.



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 9 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

4. Readings may be above or below the range set on the field instruments. The range may be reset, or the response recorded as a greater than or less than figure. The recharge rate of the well with soil gas must be considered when resampling at a different range setting.

### 7.3 Tedlar Bag Sampling

1. Follow step 1 of section 7.2 to evacuate well volume. If air monitoring instrument screening was performed prior to sample collection, evacuation is not necessary.
2. Use the vacuum box and sampling train (Figure 1) to collect the sample. The sampling train is designed to minimize the introduction or loss of contaminants due to adsorption and other factors. All parts used are either Teflon or stainless steel, and a vacuum is drawn indirectly to avoid contamination from sample pumps.
3. Place the Tedlar bag inside the vacuum box, attach it to the sampling port and open the valve. The sample probe is attached to the sampling port via Teflon tubing and a "Quick Connect" fitting.
4. Draw a vacuum around the outside of the bag, using a pump connected to the vacuum box evacuation port, via Tygon tubing and a "Quick Connect" fitting. The negative pressure inside the box causes the bag to inflate, drawing the sample into the bag.
5. Break the vacuum by removing the Tygon line from the pump. Remove the bagged sample from the box and close the valve. Record the date, time, sample location ID, and the PID/FID instrument reading(s) on sample bag label and on data sheets or in logbooks.
6. Bags should not be labeled directly with a marker or pen (particularly those containing volatile solvents) nor should adhesive labels be affixed directly to the bags. Inks and adhesive may diffuse through the bag material and contaminate the sample. Labels should be tied to the metal eyelets provided on the bags.

Chain of custody sheets must accompany all samples.

### 7.4 Sorbent Tube Sampling

Samples collected in Tedlar bags may be adsorbed onto sorbent tubes for further analysis by GC/MS.

#### 7.4.1 Additional Apparatus

Syringe, with a Luer-lock tip, capable of drawing a soil gas or air sample from a Tedlar bag onto a sorbent tube. The syringe capacity is dependent upon the volume of sample being drawn onto the tube.

Adapters, for fitting the sorbent tube between the Tedlar bag and the sampling syringe. The adapter attaching the Tedlar bag to the sorbent tube consists of a reducing union ( $\frac{1}{4}$ " to  $\frac{1}{16}$ " O.D. - Swagelok cat. # SS-400-6-ILV or equivalent) and a length of  $\frac{1}{4}$ " O.D. Teflon tubing, which replaces the nut on the  $\frac{1}{16}$ " (Tedlar bag) side. A  $\frac{1}{4}$ " I.D. Teflon or silicone O-ring replaces the ferrules in the nut on the



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 10 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

1/4" (sorberent tube) side of the union.

The adapter, attaching the sampling syringe to the sorberent tube, consists of a reducing union (1/4" to 1/16" O.D. - Swagelok Cat. # SS-400-6-ILV or equivalent) and a 1/4" I.D. Teflon or silicone O-ring, which replaces the ferrules in the nut on the 1/4" (sorberent tube) side and the needle of a Luer-lock syringe inserted into the 1/16" side (held in place with a 1/16" ferrule). The Luer-lock end of the needle can be attached to the sampling syringe. It is useful to have a Luer-lock on/off valve situated between the syringe and the needle.

Two-stage glass sampling cartridge (1/4" O.D. x 5" I.D. x 5c") contained in a flame-sealed tube containing two sorberent sections retained by glass wool:

Teflon-capped culture tubes or stainless steel tube containers for sorberent tube storage and shipping. These containers should be conditioned by baking at 120° C for at least two hours. The culture tubes should contain a glass wool plug to prevent sorberent tube breakage during transport. Reconditioning of the containers should occur between uses or after extended periods of disuse (i.e., two weeks or more).

Nylon gloves or lint-free cloth. (Hewlett Packard Part # 8650-0030 or equivalent.)

### 7.4.2 Sample Collection

Handle sorberent tubes with care, using nylon gloves (or other lint-free material) to avoid contamination.

Immediately before sampling, break one end of the sealed tube and remove the sorberent cartridge.

Connect the valve on the Tedlar bag to the sorberent tube adapter. If using a Tenax/CMS sorberent tube, connect the sorberent tube to the sorberent tube adapter with the Tenax (white granular) side of the tube facing the Tedlar bag. Connect the sampling syringe assembly to the carbon molecular sieve [CMS (black)] side of the sorberent tube. Fittings on the adapters should be finger-tight. Open the valve on the Tedlar bag. Open the on/off valve of the sampling syringe. Depending on work plan stipulations, at least 10% of the soil gas samples analyzed by field screening methods must be submitted for confirmation GC/MS analysis (according to a modified TO-17 method for sorberent tubes). Each soil gas sample must be absorbed on replicate sorberent tubes. The volume adsorbed on a sorberent tube is dependent on the total concentration of the compounds measured by field screening methods as follows:

<u>Total Concentration (ppm)</u>	<u>Sample Volume (mL)</u>
>10	Use Serial Dilution
10	10-50
5	20-100
1	100-250

After sampling, remove the tube from the sampling train with gloves or a clean



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 11 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

cloth. DO NOT LABEL OR WRITE ON THE SORBENT TUBE.

Place the sorbent tube in a conditioned stainless steel tube holder or culture tube. Culture tube caps should be sealed with Teflon tape.

Each sample tube container (not tube) must be labeled with the site name, sample number, date sampled, and volume sampled. Verify that all sample containers are properly labeled.

Chain of custody sheets must accompany all samples to the laboratory.

### 7.5 Summa Canister Sampling

1. Follow Section 7.2, step 1, to evacuate well volume. If PID/FID readings were taken prior to taking a sample, evacuation is not necessary.
2. Attach a certified clean, evacuated 6-L Summa canister via the 1/4" Teflon tubing.
3. Open valve on Summa canister. The soil gas sample is drawn into the canister by pressure equilibration. The approximate sampling time for a 6-L canister is 20 minutes.
4. Sample number, sample location, date collected and work assignment number must be recorded on a chain of custody form and on a blank tag attached to the canister.
5. Chain of custody sheets must accompany all samples to the laboratory.

## 8.0 CALCULATIONS

### 8.1 Field Screening Instruments

Instrument readings are usually read directly from the meter. In some cases, the background level at the soil gas location may be subtracted:

Final Reading = Sample Reading - Background Reading

### 8.2 Field Portable GC Analysis

Calculations used to determine concentrations of individual components by field portable GC analysis are beyond the scope of this SOP and are covered ERT/SERAS SOP #2109, *Photovac GC Analysis for Soil, Water and Air/Soil Gas*.

## 9.0 QUALITY ASSURANCE/QUALITY CONTROL

### 9.1 Sample Sorbent Tubes

Before field use, a quality assurance (QA) check must be performed on each batch of sorbent tubes by thermal desorption/cryogenic trapping GC/MS. These tubes are prepared and cleaned in accordance with EPA Method EMSL/RTP-SOP-EMD-013 by the vendor. Prior to purchasing a lot of tubes from a vendor, ten tubes from the lot are sent to the SERAS laboratory where the tubes



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 12 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

are tested for cleanliness, precision and reproducibility.

Sample tubes should be stored out of ultraviolet (UV) light (i.e., sunlight) and kept on ice until analysis. Samples should be collected in duplicate, whenever possible.

### 9.2 Sample Probe Contamination

Sample probe contamination is checked between each sample by drawing ambient air through the probe using a vacuum pump (e.g., Gilian pump) and checking the response of the FID/PID. If readings are higher than background, replacement or decontamination is necessary.

Sample probes may be decontaminated simply by drawing ambient air through the probe until the HNu reading is at background. Contamination can also be removed by decontaminating with methanol and deionized water, then air drying. For persistent contamination, use of a portable propane torch may be needed. Using a pair of pliers to hold the probe, run the torch up and down the length of the sample probe for approximately 1-2 minutes. Let the probe cool before handling. When using this method, make sure to wear gloves to prevent burns. Having more than one probe per sample team will reduce lag times between sample stations while probes are decontaminated.

### 9.3 Sample Train Contamination

The Teflon line forming the sample train from the probe to the Tedlar bag should be changed on a daily basis. If visible contamination (soil or water) is drawn into the sampling train, it must be changed immediately. When sampling in highly contaminated areas, the sampling train should be purged with ambient air, via a vacuum pump (e.g., Gilian pump), for approximately 30 seconds between each sample. After purging, the sampling train can be checked using an FID or PID, or other field monitoring device, to establish the cleanliness of the Teflon line.

### 9.4 FID/PID Calibration

The FID and PID must be calibrated at least once a day using the appropriate calibration gases.

### 9.5 Trip Blanks

A trip blank detects any sample contamination during shipping and storage. With the exception of Summa canisters, the trip blank is prepared and added to the site samples after sampling has been completed and prior to shipment.

#### 9.5.1 Tedlar Bags

Each cooler containing Tedlar bag samples must contain one Tedlar bag of ultra-zero grade air, acting as a trip blank, when samples are shipped to an outside laboratory. A chain of custody record must accompany each cooler of samples and should include the blank that is dedicated to that group of samples.

#### 9.5.2 Sorbent Tubes

At least one trip blank per cooler must be submitted with the sorbent tube samples. The ends of the sorbent tube are broken but no air is drawn through the tube.



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 13 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

### 9.5.3 Summa Canisters

Canister trip blanks are evacuated containers that are shipped to and from the site with the canisters used for air sampling.

### 9.6 Field Blanks

A field blank detects sample contamination during the handling and shipping process. The field blank must be associated with an actual sampling event.

#### 9.6.1 Tedlar Bags

For each day of sampling, a Tedlar bag is filled with ultra-zero air at the beginning of the day. The field blank is handled in the same manner as the samples.

#### 9.6.2 Sorbent Tubes

For each day of sampling, a field blank must be submitted for sorbent tubes. The ends of the sorbent tube are broken at the beginning of the day but no air is drawn through the tube.

### 9.7 Trip Standards

If Tedlar bags are used for sampling, each cooler containing samples should contain a Tedlar bag of standard gas to calibrate the analytical instruments (Photovac GC, etc.). This trip standard will be used to determine any changes in concentrations of the target compounds during the course of the sampling day (e.g., migration through the sample bag, degradation, or adsorption). A fresh trip standard must be provided and placed in each cooler pending additional sample collection. A chain of custody record must accompany each cooler of samples and should include the trip standard that is dedicated to that group of samples.

### 9.8 Lot Blanks

#### 9.8.1 Tedlar Bags

Prior to use, one bag is removed from each lot of Tedlar bags to be used for sampling and checked for possible contamination as follows: Fill the test bag with ultra-zero grade air; withdraw a sample from the bag and analyze using a field portable GC or any other applicable field instrument used for sample analysis. This procedure will ensure sample container cleanliness prior to the start of the sampling effort.

#### 9.8.2 Summa Canister Check

From each lot of four cleaned Summa canisters, one is used for a GC/MS certification check. If the canister passes certification, it is re-evacuated and all four canisters from that lot are available for sampling. If the chosen canister is contaminated, the entire lot of four Summa canisters must be re-cleaned, and a single canister is re-analyzed by GC/MS for certification.



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 14 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

### 9.8.3 Sorbent Tubes

Provide a minimum of one sorbent tube per sampling event. Do not break the ends of the tube.

### 9.9 Options

#### 9.9.1 Duplicate Samples

A minimum of 5% of all samples should be collected in duplicate (i.e., if a total of 100 samples are to be collected, five samples should be collected in duplicate). In choosing which samples to duplicate, the following criteria applies: if, after filling the first Tedlar bag and evacuating the well for 15 seconds, the second HNu reading (or other field monitoring device being used) matches or is close to (within 20%) the first reading, a duplicate sample may be taken.

#### 9.9.2 Spikes

A Tedlar bag spike and sorbent tube spike may be desirable in situations where high concentrations of contaminants other than the target compounds are found to exist (landfills, etc.). The additional level of QA/QC attained by this practice can be useful in determining the effects of interferences caused by these non-target compounds. Summa canisters containing samples are not spiked.

## 10.0 DATA VALIDATION

### 10.1 Blanks

For each target compound, the concentration found in the sample must be greater than three times the level (for that compound) found in the appropriate blank (lot, field, and trip) that accompanied that sample, to be considered valid.

## 11.0 HEALTH AND SAFETY

Because the sample is being drawn from underground, and no contamination is introduced into the breathing zone, soil gas sampling usually occurs in Level D. Nevertheless, ambient air should be constantly monitored using the HNu P101 to obtain background and breathing zone readings during the sampling procedure. As long as the levels in ambient air do not rise above background, no upgrade of the level of protection is needed.

When conducting soil gas sampling, appropriate personal protective equipment [PPE (leather gloves, steel-toed shoes, Tyvek safety suit)] should be worn, and proper slam bar techniques should be implemented. Also, an underground utility search must be performed prior to sampling (See Section 4.5).

## 12.0 REFERENCES

Gilian Instrument Corp. 1983. *Instruction Manual for Hi Flow Sampler: HFS113, HFS 113 T, HFS 113U, HFS 113 UT.*





# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 15 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

HNu Systems, Inc. 1975. *Instruction Manual for Model PI 101 Photoionization Analyzer*.

New Jersey Department of Environmental Protection. 1992. *Field Sampling Procedures Manual*.

U.S. Environmental Protection Agency. 1984. *Characterization of Hazardous Waste Sites - A Methods Manual: Volume II. Available Sampling Methods*. 2<sup>nd</sup> ed. EPA-600/4-84-076.

U.S. Environmental Protection Agency. 1995. *Superfund Program Representative Sampling Guidance. Volume 2: Air (Short-Term Monitoring)*. EPA 540-R-95/140. Interim Final.

### 13.0 APPENDICES

A - Figures

B - HNu Field Procedure



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 16 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

APPENDIX A  
Figure  
SOP # 2042  
April 2001

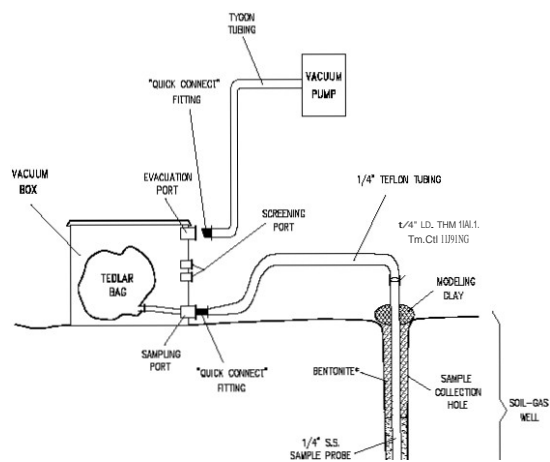


# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 17 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

FIGURE 1. Sampling Train Schematic



USED ONLY FOR SUPERMINI-TIT INSTALLATIONS



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 18 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

HNu Field Procedure  
SOP # 2042  
April 2001



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 19 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

### HNu Field Procedure

The following sections detail the procedures that are to be followed when using the HNu in the field.

#### Startup Procedure

- a. Before attaching the probe, check the function switch on the control panel to ensure that it is in the off position. Attach the probe by plugging it into the interface on the top of the readout module. Use care in aligning the prongs in the probe cord with the plug in; don't force the probe cord.
- b. Turn the function switch to the battery check position. The needle on the meter should read within or above the green battery area on the scale. If not, recharge the battery. If the red indicator light comes on, the battery needs recharging.
- c. Turn the function switch to any range setting. Look into the end of the probe for no more than two to three seconds to see if the lamp is on. If it is on, it will give a purple glow. Do not stare into the probe any longer than three seconds. Long term exposure to UV light can damage eyes. Also, listen for the hum of the fan motor.
- d. To ZERO the instrument, turn the function switch to the standby position and rotate the zero adjustment until the meter reads zero. A calibration gas is not needed for this instrument. If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted, if necessary. Wait 15 to 20 seconds to ensure that the zero reading is stable. If necessary, readjust the instrument to zero.

#### Operational Check

- a. Follow the start-up procedure.
- b. With the instrument set on the 0-20 ppm range, hold a solvent-based magic marker near the probe tip. If the meter deflects upscale, the instrument is working.

#### Field Calibration Procedure

- a. Follow the start-up procedure and the operational check.
- b. Set the function switch to the range setting for the concentration of the calibration gas.
- c. Attach a regulator to a disposable cylinder of isobutylene gas. Connect the regulator to the probe of the HNu with a piece of clean Tygon tubing. Turn on the regulator valve.
- d. After fifteen seconds, adjust the span dial until the meter reading equals the concentration of the calibration gas used. Be careful to unlock the span dial before adjusting it. If the span has to be set below 3.0, calibrate the instrument internally or return to equipment maintenance for repair.
- e. Record in the field logbook: the instrument ID no. (EPA decal or serial number if the instrument is a rental); the initial and final span settings; the date and time; concentration and type of calibration gas used; and the name of the person who calibrated the instrument.



# STANDARD OPERATING PROCEDURES

SOP: 2042  
PAGE: 20 of 20  
REV: 0.0  
DATE: 04/18/01

## SOIL GAS SAMPLING

---

### Operation

- a. Follow the start-up procedure, operational check, and calibration check.
- b. Set the function switch to the appropriate range. If the concentration of gases or vapors is unknown, set the function switch to the 0-20 ppm range. Adjust it if necessary.
- c. While taking care not to permit the HNu to be exposed to excessive moisture, dirt, or contamination, monitor the work activity as specified in the site specific Health and Safety Plan.
- d. When the activity is completed or at the end of the day, carefully clean the outside of the HNu with a damp disposable towel to remove any visible dirt. Return the HNu to a secure area and place on charge.
- e. With the exception of the probe's inlet and exhaust, the HNu can be wrapped in clear plastic to prevent it from becoming contaminated and to prevent water from getting inside in the event of precipitation.



# ACCUTEST

## SGS ACCUTEST- DAYTON STANDARD OPERATING PROCEDURE

FN: EAT002-17

Pub. Date: 08/10/1996

Rev. Date: 01/11/2017

Page 1 of 8

LAB MANAGER: Ch m an 19

QA MANAGER: Kerbyngs

EFFECTIVE DATE: 1/11/17

### Title: Summa Canister Cleaning and Certification SOP

### Revised Sections: 6.6.1 & 7.5

#### 1.0 Scope

- 1.1 This procedure applies to the cleaning, leak testing and certification of whole air and soil gas passivated sampling canisters for use in USEPA Methods TO-3, TO-15 and New Jersey Department of Environmental Protection (NJDEP) Low Level TO-15. It is applicable to 1-Liter and 6-Liter canisters that previously contained field samples, standards, lab control samples, returned unused canisters, and newly purchased canisters. This process is performed to ensure that all canisters shipped by the laboratory are free of contaminants prior to their use for field sample collection.
- 1.2 The cleanliness reporting limit for the majority of target compounds in ambient air is 0.2 ppbv with the exception of several compounds, which are higher for NJDEP LL TO-15 applications. The number of compound exceptions is greater for soil gas sampling.
- 1.3 One liter soil vapor canisters must be certified by analysis of 500ml, as required by NJDEP.
- 1.4 Canisters are categorized by their uses as either ambient air or soil gas. Each cleaning batch is specific to the canisters' use.
- 1.5 The term "canisters" referenced in this SOP applies to 1 or 6-Liter summa canisters as defined in section 5.

#### 2.0 SUMMARY

- 2.1 Passivated canisters are scrupulously cleaned using a repetitive humidified zero air pressurization and evacuation at elevated temperatures. Cleaned canisters are evacuated to approximately 30 inches of mercury (vacuum) and leak checked over a 24 hour period. The canister in the batch that contained the highest concentration of contaminants is filled with zero air and analyzed to verify cleanliness. The canister batch is certified as clean if the results are below the reporting limit for all target

compounds. The certified clean canisters are then evacuated and sealed in preparation for field sampling.

### **3.0 Reporting Limit and Method Detection Limit**

3.1 Not applicable.

### **4.0 HEALTH & SAFETY**

- 4.1 The analyst must follow normal safety procedures as outlined in the Accutest Laboratory Safety Manual which includes the use of safety glasses and lab coats. In addition, all acids are corrosive and should be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor
- 4.2 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical should be treated as a potential health hazard. Exposure to these reagents should be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets should be made available to all personnel involved in these analyses.
- 4.3 The following analytes covered by this method have been tentatively classified as known or suspected, human or mammalian carcinogens: benzene, carbon tetrachloride, chloroform, and vinyl chloride. Primary standards of these toxic compounds should be prepared in a hood. A NIOSH/Mass approved toxic gas respirator should be worn when the analyst handles high concentrations of these toxic compounds.
- 4.4 Releasing pressurized summa canisters must be performed under a ventilation hood.
- 4.5 The vent lines off the canister cleaning manifold pumps must be vented to a hood or other ventilation source.

### **5.0 Apparatus and Materials**

- 5.1 Canisters – 1 liter or 6 liter stainless steel canisters with shut off valve and ¼" threaded Swagelok sampling port. Primarily used for field samples, standards, and quality control samples. The 1-Liter variety may also be used for secondary dilutions.
- 5.2 Entech Model 3100 Cleaning System for canisters – similar pump configuration, software controlled.



- 5.3 The cleaning systems have the following manifold configuration.
- 5.4 Entech Humidification Chamber containing organic free water.
- 5.5 Entech dual- six position ovens in tandem, allowing for a batch of 12.
- 5.6 Dedicated clean pressure gauge (0-30 PSIG)
- 5.7 Zero grade air - Humidified by a humidification chamber to fill canisters during cleaning cycle along with pressurizing for leak check.

## **6.0 Cleaning Procedure**

- 6.1 Empty pressurized canisters under a hood
- 6.2 Select twelve 6-liter canisters or 16 1-Liter canisters to create a batch. Record canister serial number, previous sample number, date, canister type, cleaning cycle start/stop times and preparation batch number in Canister Preparation and Certification Logbook (Figure 1). Canister preparation batches are numbered sequentially as, CP0001, CP0002 ...etc.
- 6.3 Record each canister number of the preparation batch in the LIMs program "Summa Batch." This program is used to track canister certification status.
- 6.4 Set the controller setting for the cleaning procedure on the Entech 3100 as follows:
  - 6.4.1 Cycles: minimum 8 times for 6L, 16 times for 1L
  - 6.4.2 Rough Pump 1: 2 psia
  - 6.4.3 Final Rough pump: 2psia
  - 6.4.4 Turbo Pump 2: 1000 mtorr.
  - 6.4.5 Final Turbo: 50 mtorr for 1L and 500 mtorr for 6L
  - 6.4.6 Fill: To 20 psia
  - 6.4.7 Note: The number of cycles may be increased if a highly contaminated canister is in the batch. It is best to increase the number of cycles when a highly contaminated canister is cleaned, since the acceptance criteria for a canister cleaning is determined by the cleanliness of the canister that had the highest level of target compounds. If the selected canister does not meet the criteria, the entire batch must be re-cleaned and re-analyzed.

6.4.7.1 Certain client projects may need additional requirements to our normal cleaning procedure. Refer to Bench Notes file for details.

6.5 Prior to initiating the cleaning process, check the humidifier chamber in the cleaning unit to verify the water level is at 20-50% full, as shown by the viewing tube. Use only de-ionized water. If the water level is insufficient, add more water by removing the screw cap to the chamber while the system is at ambient pressure. Fill the chamber to the 50% mark.

#### 6.6 Canisters Cleaning Cycle Initiation

6.6.1 Attach the canisters to the manifold, open the canister valves and turn on the ovens. The oven should be set to approximately 80°C. It can be set higher but must not exceed 100°C.

6.6.1.1 The canisters may also undergo a non-heated humid zero air cleaning procedure.

6.6.2 Set the controller to **GO** and initiate the cleaning cycle as noted in section 6.4. When the procedure is finished, the controller will automatically switch to the **RUN COMPLETE** mode.

6.6.3 Once the unit is in the RUN COMPLETE mode switch the oven to off. Allow the canisters to cool and fill them to approximately 30psig with zero air, using the DILUENT button. Close each canister valve and disconnect the Swagelock fittings of the 6-liter canisters manifold.

### 7.0 Leak Testing Canisters

7.1 Once the canisters have been cleaned as described in Section 7, allowing them to equilibrate to ambient temperature is critical as a change will effect the pressure reading when leak testing the canisters.

7.2 Attach a pressure gauge to each 6-Liter canister and tighten with a wrench. Open the sampling valve and record the pressure in the logbook to the nearest 0.5psig.

7.3 Record the date and time of the initial pressure check. Remove the pressure gauge and set the canister aside for a 24 hour period to determine if vacuum deterioration from leaks occurs.

7.4 After the 24 hour leak check period has elapsed, check and record the pressure of each canister or mini-can using the same dedicated clean pressure gauge. Record the appropriate date and time of the final pressure check in the logbook the pressure change cannot be more than 2 psig for the canister top be considered leak free.

- 7.5 If a change greater than 2 psig is recorded from the initial pressure, then the canister or mini-can is suspect and should not be used. Check that all fittings and valves are tight. Refill and pressure check for another 24 hours. Record the same batch number on a new page in the canister check log, and write refer to page "" at the bottom space of the logbook. If canister fails the leak check again, mark as "Out of Service" until repair can be made.
- 7.6 After acceptable leak checks, release the pressure in the can by pointing the sampling port away from you by into an exhaust hood and opening the valve.
- 7.7 The canisters are stored at ambient pressure and the canister is ready for certification following the procedures in Section 8.

## **8.0 Canister Cleaning Certification**

- 8.1 Once canisters have been successfully cleaned and passed the leak check, one container from each batch is selected for certification by the Method TO-15
- 8.2 The canister selected for verification is the can in the batch that contained the highest concentrations of target compounds during its previous use. This data is accessed from the LIMs by entering WORKSTAT and SUMMA BATCH. Enter the canister ID's from the cleaning batch, LIMs produces a report summarizing all the target hits.
- 8.3 All TO-3 cleaning batches are certified using Method TO-3 employing a GC/PID/FID system. All TO-15 batches are certified by GC/MS.
- 8.4 Release any overpressure from the selected canister to assure ambient pressure (Section 7.6). For method TO-3, analyze 0.5cc of sample via a loop injector. For method TO-15, analyzing 400cc of this canister represents a dilution factor of one since calibration is based on 400cc of the calibration standards. The canister selected is documented in the logbook with the analysis date and data file used for certification.
- 8.5 Once the analysis is completed, review the data. All the results must be < RL, the canisters from the batch can be evacuated as described in Section 9 and shipped for sampling.
  - 8.5.1 Check Project Bench Notes for Client Specific Criteria.
  - 8.5.2 If the results do not meet the criteria repeat the cleaning procedure in Section 6 and the Leak Test Procedure in Section 7, for all canisters in the cleaning batch.

## **9.0 Final Canister Evacuation**

- 9.1 Re-attach the canisters at ambient pressure from the same preparation batch to the Entech evacuation manifold.
- 9.2 Recall and initiate EVAC program on the Entech. Open the valve on each canister to initiate the evacuation process. Pump the system down to <50mtorr or 0.050 mm Hg (approximately 45 minutes).
- 9.3 When the vacuum is <50mtorr on the digital readout, record the vacuum value and close the canister valves. Click the STOP button with the mouse cursor.
- 9.4 Vacuum readings <0.050mm Hg or 50mtorr are considered full vacuum and will read approximately 29.4" Hg (vac) on a vacuum gauge. Record the date, initials, and final mtorr reading in the canister preparation logbook (Figure 7).
- 9.5 Remove the canisters and cap with the ¼" nut with a wrench. Do not over tighten; the nuts are soft brass and can be easily stripped.
  - 9.5.1 The canister's On/Off valve seals the vacuum. Tightening the nut is an additional seal to protect the sampling port from outside contamination.
- 9.6 Once the canisters have undergone the final evacuation, they can be stored in the laboratory for 2 months.

## **11.0 Client Canister Retention**

- 11.1 Canisters that have been shipped from the laboratory are no longer under controlled laboratory conditions. A 15 day period is the maximum allowed field holding period.
- 11.2 Canister tags are labeled with the "Initials, Expiration and Certification Dates in month/day/year format.
- 11.3 All canisters transferred from controlled storage must be returned to the lab for re-cleaning and certification. This requirement applies to any canisters that were not used for sampling, but were stored in an uncontrolled environment.

## **12.0 Documentation Requirements**

- 12.1 Assign new canisters a serial number utilizing stick on labels with the Accutest Laboratories name and address.

12.2 Complete all the sections of the Canister Preparation and Certification Log to ensure a full audit trail of each canister.

12.3 Canister Preparation Batch number and associated canisters must be entered in the LIMs **Summa Batch** program in order to link canister cleaning information to samples received.

### **13.0 POLLUTION PREVENTION & WASTE MANAGEMENT**

13.1 Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents, and solvents must be limited to the amounts specified in this SOP. All safety practices designed to limit the escape of vapors, liquids or solids to the environment must be followed. All method users must be familiar with the waste management practices described in section 13.2.

13.2 Waste Management. Individuals performing this method must follow established waste management procedures as described in the waste management SOP, EHS004. This document describes the proper disposal of all waste materials generated during the testing of samples as follows:

13.2.1 Non hazardous aqueous wastes.

13.2.2 Hazardous aqueous wastes

13.2.3 Chlorinated organic solvents

13.2.4 Non-chlorinated organic solvents

13.2.5 Hazardous solid wastes

13.2.6 Non-hazardous solid wastes

### **14.0 METHOD REFERENCE**

14.1 Method TO-14A, "Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis", Jan 1999" Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition"

14.2 Method TO-15, "Determination Of Volatile Organic Compounds (VOCs) In Air Collected In Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)", Jan 1999 from "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition"



**SGS ACCUTEST- DAYTON  
STANDARD OPERATING  
PROCEDURE**

FN: EAT002-17  
Pub. Date: 08/10/1996  
Rev. Date: 01/11/2017  
Page 8 of 8

14.3 NJDEP- SRP Low Level USEPA TO-15 Method (NJDEP-LLTO-15-3/2007), March 2007, Revised March 2009

LAB MANAGER: *Q. M. B.*

QA MANAGER: *Joseph Raimo*

EFFECTIVE DATE: *9/11/2017*

TITLE: AIR ANALYSIS BY TO-15

REFERENCES: EPA TO-15 AND TO-15 NJDEP-LL

REVISED SECTIONS: 12.3.3, 13.6.2

## 1.0 SCOPE AND APPLICATION

- 1.1 This method is for the analysis of volatile organics on whole ambient air samples collected in summa canisters. This procedure is applicable to all compounds listed under EPA method TO-15 as the cryofocusing technique can trap a wide range of polar and non-polar compounds.

## 2.0 METHOD SUMMARY

- 2.1 A whole air sample collected in a summa passivated canister or Restek "Silcocan", is concentrated by adsorption and cryofocusing and introduced into a GC/MS for target compound analysis.
- 2.2 The GC/MS is calibrated with a minimum 5 level curve with quantitation performed by internal standard technique. Standards are purchased as commercial certified gas standards and dynamically diluted into working calibration standards.
- 2.3 A nominal sample volume of 400cc is used and adjusted if necessary based on dilutions and/or canister pressurization. Air is drawn out of a canister and trapped on a glass bead trap, tenax trap and cyrofocused prior to introduction into the GC/MS. The GC oven is temperature programmed to separate the compounds of interest with detection by a mass selective detector.
- 2.4 This method is applicable to the compounds listed on Table 5 which, are routinely calibrated.

## 3.0 REPORTING LIMIT AND METHOD DETECTION LIMIT

- 3.1 Reporting Limit. The reporting limit for this method is established at the low calibration standard used in the analysis. Detected concentrations below these reporting limits cannot be reported without qualification. Total volatiles based on total peak areas as calibrated to the total area of pentane or heptane have a reporting limit of 10ppbv. See Table 5.
- 3.2 Method Detection Limit Study. Experimentally determine MDLs using the procedure specified in 40 CFR, Part 136, Appendix B.

- 3.2.1 Experimental MDLs must be determined annually for this method. The spike concentration must be at or below the reporting limit.
- 3.2.2 MDL studies are to be performed with volumes of spiked zero air that is routinely analyzed for live samples (i.e. 400cc).
- 3.2.3 Process all raw data for the replicate analysis in each MDL study. Forward the processed data to the QA group for archiving.

## 4.0 DEFINITIONS

**CALIBRATION FACTOR (CF)** - a measure of the gas chromatographic response of a target analyte to the mass injected. The calibration factor is analogous to the Relative Response Factor (RRF) used in the Volatile and Semivolatile fractions.

**CONTINUING CALIBRATION** - analytical standard run every 24 hours to verify the initial calibration of the system.

**INITIAL CALIBRATION** - analysis of analytical standards for a series of different specified concentrations; used to define the linearity and dynamic range of the response of the mass spectrometer to the target compounds.

**MATRIX DUPLICATE** - a second aliquot of the same matrix as the sample analyzed in order to determine the precision of the method.

**METHOD BLANK** - an analytical control consisting of all reagents, internal standards and surrogate standards (or SMC's for VOA), that is carried throughout the entire analytical procedure. The method blank is used to define the level of laboratory, background and reagent contamination.

**METHOD DETECTION LIMIT (MDL)** The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. MDLs are determined approximately once per year for frequently analyzed parameters.

**PERCENT DIFFERENCE (%D)** - As used in this SOW and elsewhere to compare two values, the percent difference indicates both the direction and the magnitude of the comparison, i.e., the percent difference may be either negative, positive, or zero. (In contrast, see relative percent difference.)

**RELATIVE PERCENT DIFFERENCE (RPD)** - As used in this SOW and elsewhere to compare two values, the relative percent difference is based on the mean of the two values, and is reported as an absolute value, i.e., always expressed as a positive number or zero. (In contrast, see percent difference.)

**REPORTING LIMIT (RL)** – The reporting limit is established at either the method detection limit or the lowest concentration standard in the calibration curve, depending on the requirements of different specific regulatory programs. Detected concentration below this concentration cannot be reported without qualification.

**ZERO AIR** – Ultra purity grade commercially available compressed air. Contains less than 0.1ppm of hydrocarbons, 1ppm of carbon dioxide and carbon monoxide, and less than 5ppm moisture.



## **5.0 HEALTH & SAFETY**

- 5.1 The analyst must follow normal safety procedures as outlined in the SGS Accutest Laboratory Safety Manual which includes the use of safety glasses and lab coats. In addition, all acids are corrosive and must be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor
- 5.2 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical must be treated as a potential health hazard. Exposure to these reagents must be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets must be made available to all personnel involved in these analyses.
- 5.3 The following analytes covered by this method have been tentatively classified as known or suspected human or mammalian carcinogens: benzene, carbon tetrachloride, chloroform, and vinyl chloride. Primary standards of these toxic compounds must be prepared in a hood. A NIOSH/Mass approved toxic gas respirator must be worn when the analyst handles high concentrations of these toxic compounds.
- 5.4 Releasing pressurized summa canisters must be performed under a ventilation hood.

## **6.0 HOLDING TIME & PRESERVATION**

- 6.1 30 days for canisters from collection to analysis.
- 6.2 Summa Canisters are stored at ambient temperature.

## **7.0 INTERFERENCES**

- 7.1 High CO<sub>2</sub> samples such as landfill gas may freeze and restrict flow on the traps causing reduced sample volume.
- 7.2 Common laboratory solvents such as methylene chloride, ethanol, hexane, iso-propanol, freon-113 and acetone may be detected at low level concentrations. The values qualified with a "B" if they are also detected in the method blank.
- 7.3 Isopropanol and Ethanol(as described in TO15 NJDEP-LL)

7.3.1 High concentrations of isopropanol and ethanol in indoor air samples are causing laboratories to conduct unnecessary dilutions of samples. These two alcohols are present in numerous products found in residences and businesses. Ethanol is also a gasoline additive. This is one source of the elevated levels of the alcohols in the samples.

7.3.2 The commercial gas suppliers are routinely adding these two compounds to the standard gas mixtures; therefore, if the compounds are in the standards, the concentrations of the compounds must be reported in the samples. Ethanol has been reported by the standard manufacturers not to be stable within the standard mixtures.

7.3.3 Isopropanol is used as tracer gas compounds for soil gas analysis. The presence of this compound in soil gas samples may be an indication that the seal around the tubing was not tight. However, the presence of these compounds in soil gas when the alcohols were not used as the tracer gas may be indication of another source of contamination.

7.3.4 If these compounds are of concern at site, then this method may not be appropriate for the reporting of these compounds and a different method will be proposed. Laboratory certification will be required for any proposed method.

7.3.5 The laboratory is not required to dilute the sample to bring the concentration of the two alcohols compounds within the calibration range of the instrument.

## **8.0 APPARATUS**

- 8.1 Hewlett Packard 5890 series II GC with 5971 MSD,
- 8.2 Agilent 6890 GC with 5973 MSD.
- 8.3 Agilent 6890 and 7890A GC with 5975 MSD
- 8.4 PC based Hewlett Packard Chemstation with Enviroquant software.
- 8.5 Entech model 7016CA 16-position canister autosampler.
- 8.6 Entech model 7100 pre-concentrator.
- 8.7 30"Hg-30psig "NIST" traceable pressure/vac gauge, accurate to 0.25%, for sample receipt check and pressurization, if necessary.
- 8.8 1- Liter certified (as per SOP EAT002) "mini" canisters or silcocans evacuated to under 0.05mm Hg.
- 8.9 6- Liter certified (as per SOP EAT002) passivated summa canisters or silcocans evacuated to under 0.05mm Hg. A separate group must be maintained for method blank analysis
- 8.10 Passive flow controllers equipped with particulate filter – Entech CS1200 or equivalent
- 8.11 Flow controller critical orifices for varying sampling time ranges (see table 10).
- 8.12 Digital Flow Meter for flow controller calibration
- 8.13 Various gas tight syringes for standard and sample dilutions.
- 8.14 Various swagelok fittings.
- 8.15 Syringe adapters for summa canisters if manual injection or dilution needed.
- 8.16 Tedlar Bags – for secondary sample dilutions.

## 9.0 STANDARDS AND REAGENTS

The manufacturer brands listed may be substituted with equivalent standards. Refer to table 5 for a list of compounds in the TO-14 reporting list, TO-15 reporting list, and add-on compounds.

9.1 Spectra Gases certified internal/surrogate gas standard at the following concentrations.

- Bromochloromethane 40ppbv
- 1,4-Difluorobenzene 40ppbv
- Chlorobenzene-d5 40ppbv
- 4-bromofluorobenzene 40ppbv

9.2 Spectra Gases certified 1ppmv TO-15 stock gas standard.

9.3 Spectra Gases certified 1ppmv second source TO-15 stock gas standard (for LCS)

9.4 Spectra Gases 1ppmv Napthalene gas standard with 3ppmv Bromoform as a stabilizer.

9.5 Absolute Standards 1000 ug/ml naphthalene standard in methanol.

9.6 Reagent grade organic free water.

9.7 Air Gas brand Ultra Zero Grade air

9.8 Air Gas brand Ultra High Purity (UHP) helium

9.9 Air Gas liquid nitrogen Dewar

9.10 Standards dilution canister preparation

9.10.1 All canisters must be certified and under full vacuum.

9.10.2 Make sure sampling valve is closed. Using a wrench, remove the protective swagelok cap exposing the ¼" threaded sampling port.

9.10.3 Add 80ul of organic free reagent grade water into the threaded port of the evacuated 6-Liter canister and attach a syringe adaptor for standard introduction.

9.11 Stock gas standard preparation

9.11.1 Place the stock gas standard cylinder of interest in or near the evacuation hood and attach syringe adaptor to gas regulator.

9.11.2 Turn on stock standard valve and regulate delivery pressure to approximately 5psig and let purge for a few seconds.

9.11.3 Attach gas tight standard syringe and draw a full volume to rinse. Expel contents under the hood and proceed to standard concentration of interest.

## 9.12 Calibration Standards

### 9.12.1 **40ppbv “standard” compound list**

- 9.12.1.1 With a 500cc gas tight syringe, measure 400cc of the 1ppm stock standard.
- 9.12.1.2 Attach the syringe to a prepared 6-Liter canister.
- 9.12.1.3 Open the sampling valve and draw in the entire 400 cc.
- 9.12.1.4 Close the valve and remove the syringe adaptor.
- 9.12.1.5 Attach a zero air supply to the canister equipped with a fine metering regulator and a NIST vacuum/pressure gauge.
- 9.12.1.6 Adjust the air pressure regulator to 9.8psig and slowly open the canister sampling valve only enough to hear the air draw but keeping a positive reading on the NIST gauge reading from dipping below 0 psig.
- 9.12.1.7 The final pressure of 9.8psig equates to an actual volume of 10-liters in a 6-liter canister.
- 9.12.1.8 Once the pressure equilibrates, first close the canister valve and then the air supply.
- 9.12.1.9 Let standard equilibrate for 30 minutes prior to use.

### 9.12.2 **2ppbv “standard” compound list**

- 9.12.2.1 With a 500cc gas tight syringe, measure 500cc of the 40ppbv standard that is equipped with a syringe adaptor.
- 9.12.2.2 Follow the remaining steps outlined in 9.12.1.2 through 9.12.1.9

### 9.12.3 **0.4ppbv “standard” compound list**

- 9.12.3.1 With a 500cc gas tight syringe, measure 100cc of the 40ppbv standard that is equipped with a syringe adaptor.
- 9.12.3.2 Follow the remaining steps outlined in 9.12.1.2 through 9.12.1.9

### 9.12.4 **0.1ppbv “standard” compound list**

- 9.12.4.1 With a 500cc gas tight syringe, measure 1cc of the 1ppm standard that is equipped with a syringe adaptor.
- 9.12.4.2 Follow the remaining steps outlined in 9.12.1.2 through 9.12.1.9

## 9.13 Blank Spike (BS)Laboratory Control Standard (LCS)

### 9.13.1 **40ppbv BS standard**

- 9.13.4.1 Follow the same procedure as 9.12.1 using the 1ppmvBS stock standards.

9.13.4.2 100cc of this standard is used for an equivalent 10ppbv BS.

#### 9.14 Method Blank

9.14.1 A separate stock of canisters is maintained for use exclusively as method blanks. These canisters are not to be used for field sampling.

9.14.2 Inject approximately 80ul of organic free reagent water into the threaded port of an evacuated 6-Liter canister. Do not open valve as the water will be drawn in when the zero air is attached.

9.14.3 A 6 liter evacuated canister is filled and pressurized to approximately 15 psig with zero grade air.

#### 9.15 Working Standards Storage Period

9.15.2 Any working standards or LCS must not be used after 30 days from preparation or of the stock standard expiration date if this date is sooner. An expiration date of 30 days after the preparation date must be documented on the standards tag and standards logbook.

## 10.0 SUMMA CANISTER HANDLING

10.1 Canister Cleaning and Certification – Refer to SGS Accutest Laboratories SOP EAT002

#### 10.2 Canister Shipping

10.2.1 Record prepared certified summa canister (Refer to SOP EAT002) and vacuum in canister logbook. Vacuum must be recorded to the nearest 0.2" hg Vacuum.

10.2.2 Grab samples are summa canisters without flow controllers taking about 20 seconds to fill.

#### 10.3 Flow Controller Calibration

10.3.1 For integrated sampling, a canister must be equipped with a clean calibrated detachable flow controller.

10.3.2 Select and install the appropriate critical orifice (table 10) that corresponds to the desired sampling period.

10.3.3 The flow controller is calibrated by attaching it to a clean summa canister under vacuum and adjusting the flow control calibrator while measuring the flow in cc/min with a flow meter.

10.3.4 Slight vacuum (1 to 8"Hg) remains in the canister after sampling to indicate a consistent sampling event. Therefore the flow controller is calibrated at a rate not to completely fill the canister.

- 10.3.5 For a 24 hour sample, a flow of 3.8cc/min theoretically fills a 6-Liter canister with 5.47 liters of sample (3.8cc/min)(60min)(24 hr).

#### 10.4 Canister Receipt

- 10.4.1 Upon receipt of the canister, the pressure or vacuum must be checked to ensure proper sampling was performed. If excessive vacuum ( $>15$ " Hg) is measured the client is notified to inquire about the shortened sampling period and re-sampling.
- 10.4.2 The pressure or vacuum along with received date and lab sample number must be recorded in the canister logbook to the nearest 0.2 "hg vacuum or 0.2 psig if under positive pressure.
- 10.4.3 Canisters received at greater than or equal to 8" Hg vacuum, must be pressurized to ensure sample draw with the diaphragm pump.
- 10.4.4 Canisters pressurized upon receipt must not exceed 6.5 Liters total. Refer to the "Canister Pressurization Calculation" in table 6.
- 10.4.5 If a flow controller was supplied, the flow must be verified upon receipt and recorded in the logbook.

#### 10.5 Canister Retention Time

- 10.5.1 Canisters that are shipped from the lab are no longer considered as being stored under controlled conditions. A 15 day period is the maximum allowed field holding period.
- 10.5.2 All canisters transferred out of controlled storage must be returned to the lab for recleaning and certification. This requirement applies to canisters that were not used for sampling, but were stored in an uncontrolled environment.
- 10.5.3 In-house canister retention time. Once the canisters have undergone the final evacuation as detailed in SOP EAT002, they may be stored in the laboratory for 2 months.

### 11.0 CALIBRATION

#### 11.1 Entech Autosampler/ Concentrator conditions

- 11.1.1 7016CA autosampler Valve: 100°C
- 11.1.2 Transfer Line: 80°C

### 11.1.3 7100 Concentrator

	<u>Internal</u>	<u>Standard</u>	<u>Sample</u>	<u>Sweep Gas</u>	<u>Transfer</u>
Preflush (sec)	5	2	15	5	-
Flow Rate (sccm)	100	150	150	100	15
Vol (cc/min)	100	varies	varies	75	40

Note: the mass flow controller may have a false reading in standby, as in 5 or 6. The trapping cc/min must be increased by this amount as per the manufacturer (100 must be set at 105 or 106 in this case).

	<u>Trap</u>	<u>Preheat</u>	<u>Desorb</u>	<u>Bake</u>
Module 1	-150 °C	20 °C	20 °C	150 °C/ 10 min
Module 2	-10 °C	no	180 °C	190 °C/ 3.5 min
Module 3	-150 °C	100 °C	4.5min	100 °C/ 3min

GC/MS Transfer line 100 °C

Total event cycle time 35 min

### 11.2 GC Conditions

11.2.1 Hewlett Packard 5980 or Agilent 6890 gas chromatograph.

11.2.2 Column – Restek 60 meter RTX-1, 0.25mm id, 1.0 um film thickness.

11.2.3 Helium carrier gas at approx. 12psig column head pressure.

11.2.4 GC Temperatures:

Injection port	120 °C
Detector	280 °C
Oven	40 °C held for 5min 8 °C /min to 210 °C and held for 0.0min 25 °C/min to 260 °C and held for 3.0min
Total runtime	29.25 min
Electronic Pressure Control:	Constant Flow at 1.4cc/min
Purge Valve	Off at 1.00 min

11.2.5 Optimize GC conditions for compound separation and sensitivity. Baseline separation of benzene and carbon tetrachloride is an indication of acceptable chromatographic performance.

### 11.3 Mass Spectrometer Conditions

- 11.3.1 Hewlett Packard 5971, Agilent 5973, or Agilent 5975 MSD with linear quadrupole.
- 11.3.2 Scan from 35-300 amu every 1.0 seconds or less utilizing a 70 volt (nominal) electron energy in the electron impact ionization mode.
- 11.3.3 Set baseline noise threshold to 250 with a solvent delay of approximately 3.3 minutes or just before the elution of propylene.
- 11.3.4 Mass spectrum must meet all the criteria in Table 1 when injecting 100cc of 20ppbv 4-Bromofluorobenzene (BFB). This is equivalent to 5ppbv when considering a 400cc nominal volume.

### 11.4 Data System

- 11.4.1 A computer system containing the latest compatible version Hewlett Packard chemstation software interfaced to the mass spectrometer.
- 11.4.2 Set the data acquisition mode method to the conditions described in 12.3.  
The software performs continuous acquisition and storage on machine- readable media (disc) of all mass spectra obtained throughout the duration of the chromatographic program.
- 11.4.3 The data analysis mode method defines each compound retention time, characteristic ions (table 4), and calibration to identify and quantify each compound in the data file.
- 11.4.4 The quantitation is performed by internal standard option using multi-point calibration and multipoint internal standards.
- 11.4.5 The NIST mass spectral library (75,000 compounds) is used for non- target peak tentative identification.

### 11.5 Daily BFB system performance tuning.

- 11.5.1 The 40ppbv internal standard and 40ppbv surrogate is attached to the internal standard port of the Entech 7100 utilizing flushed 1/8" copper tubing.
  - 11.5.1.1 The BFB standard is prepared in humidified zero air.
- 11.5.2 100cc of this standard is sampled which is equivalent to 5ppbv of BFB.
- 11.5.3 The GC/MS and Entech concentrator conditions are the same as in section 11.1-11.3.
- 11.5.4 Evaluate the tune spectrum using three mass scans from the chromatographic peak and a subtraction of instrument background.



11.5.4.1 Select the scans at the peak apex and one to each side of the apex.

11.5.4.2 Calculate an average of the mass abundances from the three scans.

11.5.5 Background subtraction is required. Select a single scan in the chromatogram that is absent of any interfering compound peaks and no more than 20 scans prior to the elution of BFB. The background subtraction is designed only to eliminate column bleed or instrument background ions. Do not subtract part of the tuning. Spectra of the background subtracted BFB peak must be checked to verify acceptable performance criteria are achieved (see Table 1).

11.5.6 This performance test must be passed before any samples, blanks, or standards are analyzed.

11.5.7 If all the criteria are not achieved, the analyst must retune the mass spectrometer and repeat the test until all criteria are met.

11.5.8 The injection time of the acceptable tune analysis is considered the start of the 24-hour clock.

## 11.6 Initial Calibration

11.6.1 All volumes are calculated based on a nominal volume of 400cc.

11.6.2 A multi-level calibration is performed utilizing 0.04, 0.1, 0.2, 0.5, 5, 10, 20, and 40 ppbv. For Selective Ion Monitoring (SIM) analysis the initial calibration curve uses lower concentration standards than normal analysis. Typical ICAL levels are 0.001, 0.005, 0.01, 0.02, 0.05, 0.1, and 0.2ppbv

11.6.2.1 The 0.2ppbv standard, with the exception of propylene and ethanol, must be part of the calibration curve to satisfy the reporting limits. The propylene and ethanol curves must contain the 0.5ppbv.

11.6.2.2 Saturation may occur on some of the highly polar compounds (alcohols, 1,4-dioxane) that may require removing of the 40ppbv standard from the calibration curve in order to meet criteria.

11.6.2.3 A minimum of 5 calibration points must be used for each compound.

11.6.2.4 A 0.04ppbv may be analyzed for limited projects and limited compounds upon client request.

11.6.3 The 0.4, 2.0 and 40ppbv calibration standards are attached to sample ports on the Entech 7100.

11.6.4 Considering a nominal volume of 400cc, volumes of 40cc and 100cc are sampled from the 0.4ppbv standard (9.12.3) for the 0.04 and 0.1 standards respectively. Volumes of 40cc and 100cc are sampled from the 2ppbv standard (9.12.2) for the

0.2 and 0.5, standards. Volumes of 50, 100, 200 and 400 are sampled from the 40ppbv standard (9.12.1) for the 5, 10, 20, and 40ppbv.

- 11.6.5 For Selective Ion Monitoring (SIM) analysis considering a nominal volume of 400cc using the 0.1 ppb standard (9.12.4) use volumes of 800cc, 400cc, 200cc, 80cc, 40cc and 20cc for the 0.2, 0.1, 0.05, 0.02, 0.01, 0.05ppbv standards, and 40cc of the 0.01ppbv standards for the 0.001ppbv standard.
- 11.6.6 Internal standard/ surrogate- volume is 100cc of the stock standard (8.1) for all standards, samples and quality control resulting in a 10ppbv internal standard and 5ppbv surrogate standard concentration.
- 11.6.7 Detector Saturation - Occasionally, several compounds in higher concentration standards exhibit chromatographic peak saturation. Unsymmetrical peaks that initially appear to be symmetrical that exhibit a perpendicular drop to the baseline are characteristic of peak saturation. The apex of a saturated peak looks abnormal and may exhibit a plateau. Saturated chromatographic peaks must not be used in the calibration curve and must be eliminated from the calibration. This results in decreased concentration for the upper calibration range limit.
- 11.6.8 The Relative Response Factor (RRF) is calculated for each compound at every standard level.
- 11.6.9 Mean Relative Response Factor - Calculate the average of the values obtained at the five concentrations.
- 11.6.10 Percent Relative Standard Deviation (% RSD) is calculated for all calibration levels
- 11.6.11 Calculate the Relative Retention Time (RRT) for each target compound over the initial calibration range.
- 11.6.12 Mean Relative Retention Time- Calculate the mean of the relative retention times for each analyte target compound over the initial calibration range.
- 11.6.13 The following criteria must be met for the initial calibration to be valid.
  - 11.6.13.1 The percent relative standard deviation must be less than 30 %, with the exception of naphthalene.
  - 11.6.13.2 Up to two compounds may exceed 30% but must be less than 40% for a valid initial calibration, with the exception of naphthalene.
  - 11.6.13.3 The relative retention time for each target compound at each calibration level must be within 0.06 RRT units of the mean relative retention time for the compound.
  - 11.6.13.4 The area response of each calibration level must be within 40% of the mean area response over the initial calibration range for each internal standard.

11.6.13.5 The retention time shift for each of the internal standards at each calibration level must be within 20 seconds (0.33 minutes) of the mean retention time over the initial calibration range for each internal standard.

11.6.13.6 If the acceptance criteria are not met due to peak saturation the high standard can be dropped for that compound, but a minimum of 5 standards must be used. This will lower the upper calibration range and may require additional dilutions. If a particular standard(s) are the cause of the failure, rerun that standard(s) one time only. If this fails then the calibration curve must be rerun.

#### 11.7 Continuing calibration

11.7.1 A continuing calibration check standard is analyzed at 10ppbv, which is equivalent to 100cc of the 40ppbv standard. Calibration checks must be acquired every 24 hrs.

11.7.2 A 10ppbv naphthalene standard is analyzed every 24 hours when samples are requested for naphthalene. A 10ppbv standard is equivalent to 100cc of the 40ppbv naphthalene standard.

11.7.3 The percent difference (%D) for all continuing calibration compounds must be less than 30%.

11.7.4 If the continuing calibration check fails to meet the criteria, it is repeated one time. If it fails a second time, corrective action is taken and two consecutive CCVs must pass in order to continue with sample analysis or a new initial calibration must be performed.

11.7.4.1 Corrective Action may include but is not limited to: tuning the instrument, cleaning the source, changing or clipping the column. All maintenance must be recorded in the maintenance logbook.

11.7.4.2 If retuning is performed due to a first failed CCV, the BFB may be reported out of the second CCV run.

#### 11.8 Initial Calibration Verification (ICV) Second Source Standard

11.8.1 Prepare the second source calibration check standards from separate sources of stock standards from the calibration curve. An ICV must be analyzed immediately after each initial calibration.

11.8.1.1 The percent difference (%D) for all target compounds must be less than 30 % for all compounds.

11.8.1.2 The ICV acceptance criteria must be met before any samples are analyzed. If there are compounds outside of the acceptance criteria, samples may be analyzed if these compounds are nontarget.

#### 11.9 TO-15 SIM analysis

11.9.1 For SIM analysis, the Scan Parameters are changed. Scanning windows are established in the instrument run method which uses a minimum of one target ion and one

secondary ion for each target analyte. Appropriate time is allowed for the elution of each peak of interest.

11.9.2 Initial Calibration is performed using concentrations of 0.001, 0.005, 0.01, 0.02, 0.05, 0.1 and 0.2ppb. For SIM compounds the % RSD must be less than or equal to 30%.

11.9.3 Prepare the second source calibration check standards from separate sources of stock standards from the calibration curve. An ICV must be analyzed immediately after each initial calibration. The ICV must be analyzed at a concentration of 0.05 ppbv.

11.9.3.1 The percent difference(%D) for all SIM compounds on the must be less than 30 %.

11.9.3.2 If the ICV fails to meet the criteria then the compounds that failed must not be reported for that Initial Calibration.

11.9.4 A continuing calibration check standard is analyzed at 0.05 ppbv Calibration checks must be acquired every 24 hrs.

11.9.4.1 The percent difference (%D) for all continuing calibration compounds must less than 30%.

11.9.4.2 If the continuing calibration check fails to meet the criteria, it is repeated one time. If it fails a second time, corrective action is taken and a new initial calibration must be performed.

## **12.0 SAMPLE ANALYSIS**

### **12.1 Internal Standard**

12.1.1 100 cc of the internal/ surrogate standard is equivalent to 10ppbv that is added to all standards, samples and QC.

12.1.2 If any of the internal standard areas change by greater than +/-40% or retention time changes by more than 0.33 minutes from the last daily calibration check standard the mass spectrometer must be inspected for malfunctions and corrections be made, as appropriate.

### **12.2 Method Blank**

12.2.1 A separate stock of canisters is maintained for use exclusively as method blanks. These canisters are not to be used for field sampling.

12.2.2 To monitor for possible laboratory contamination, laboratory method blanks are analyzed at least once in a 24-hour analytical sequence. All steps in the analytical procedure are performed on the blank

- 12.2.3 A volume of 400cc is sampled from the method blank as prepared in 10.5. This volume is the most dilution air that could be added to any sample to verify the dilution air source along with the procedure is non-detect for all compounds.
- 12.2.4 Method blanks are analyzed and evaluated before any samples can be run and must be less than the MDL for all target compounds. The surrogate must meet the generated in-house acceptance criteria in LIMS. Occasionally, lab background such as isopropanol cannot be fully eliminated and is flagged appropriately in any samples
- 12.2.5 If the method blank fails to meet these criteria the source of contamination must be determined and the method blank be rerun before any samples are run.

### 12.3 Blank Spike (BS) and Blank Spike Duplicate (BSD).

- 12.3.1 A Blank Spike (BS) is prepared to contain 40ppbv each analyte .100 cc of the BS is sampled in duplicate BSD for a 10ppbv.
- 12.3.2 Percent recoveries (% R) (see section 14.2) must fall within 70-130%. All of the compounds must be within acceptable ranges with one exception. The BS is acceptable if a few compounds have a bias high recovery as long as no hits are reported in associated samples.
- 12.3.3 Relative Percent Difference (RPD) (see section 14.3) must be less than or equal to 25%. All of the compounds reported as target compounds must be within acceptable ranges.
- 12.3.4 If laboratory control samples do not meet criteria, calculations are checked. A new BS must be prepared and analyzed and possibly a new calibration if the problem isn't rectified.

### 12.4 Sample analysis – General

- 12.4.1 Unknown samples are screened by the TO-3/PID/FID system or a GC/MS system dedicated to screening.
- 12.4.2 A sample volume of 400cc at ambient temperature and pressure is standard for analysis to achieve the reporting limits required. Smaller sample amounts down to 20 cc can be sampled accurately with the concentrators mass flow controller.
- 12.4.3 Sample volumes are adjusted accordingly (table 6) when canisters are received with excess vacuum and require dilution air (8.7) in order for the concentrator to draw an accurate volume.
- 12.4.4 Samples requiring further dilution beyond the minimum 20cc (greater than 20X) that can be sampled from the primary sample canister are prepared as secondary dilutions in additional canisters or tedlar bags. This practice is commonly used for soil vapor samples.
- 12.4.5 Secondary dilution information is recorded in the secondary dilution log (table 7).

## 12.5 Summa canister sample analysis

12.5.1 Check canister pressure and document upon laboratory receipt.

12.5.2 The canister is pressurized upon receipt if excessive vacuum remains at receipt ( $\geq 8$  "Hg). If the canister is pressurized, the sampling volume must be adjusted to compensate for the dilution. Refer to the "Canister Pressurization Calculation" in Table 6.

## 12.6 Sample Dilution

- 12.6.1 Less sample volume can be designated by the concentrator software down to 20cc. With normal volume being 400cc, this would result in a 1:20 dilution. Further dilutions require a dilution into a secondary vessel.
- 12.6.2 To manually draw a volume out of a canister, positive canister pressure is required.
- 12.6.3 To perform a secondary dilution, the canister vacuum at the time must be recorded. This vacuum varies from the received vacuum if sample has already been drawn.
- 12.6.4 Record the vacuum in the "Canister Secondary Dilution" log. Refer to table 7.
- 12.6.5 When pressurizing the canister for a manual sample draw, the volume of a 6-Liter canister must not exceed 6.5-Liters. Refer to Table 8 for the proper pressurization.
- 12.6.6 A measured volume of the newly pressurized original canister is drawn out with a gas-tight syringe and introduced into a secondary vessel (6-Liter, 1-Liter canister or 1-Liter tedlar bag). The secondary vessel is diluted with zero grade air.
- 12.6.7 The final sample dilution factor (DF) is calculated by (original canister dilution factor) x (secondary vessel dilution factor) x (instrument dilution factor). The instrument dilution factor is the nominal volume of 400cc/ amount of sample introduced by the auto sampler. An example calculation of a final sample multiplier is as follows;
  - 12.6.7.1.1 Original canister is pressurized to a factor of 1.2
  - 12.6.7.1.2 The amount introduced to the dilution vessel results in an additional factor of 10
  - 12.6.7.1.3 The autosampler introduces 40cc from the secondary vessel for an additional factor of  $400/40 = 10$
  - 12.6.7.1.4 Final sample multiplier =  $1.2 \times 10 \times 10 = 120$

## 13.0 QUALITY CONTROL

### QC Requirements Summary:

BFB.	Every 24 hrs.
Initial Calibration(IC)	As needed
Calibration Check Std(CCV).	Every 24 hrs.
Initial Calibration Verification (ICV)	After every IC
Batch blank	Every 24 hrs.
Matrix Duplicate	one per 20 samples
Blank Spike (BS)	one per 20 samples
Blank Spike Duplicate (BSD)	one per 20 samples
Surrogate	every sample and standard.
Internal Standard	every sample and standard.

13.1 Daily GC/MS Performance Check - refer to section 11.5.

13.2 Initial Calibration - Refer to section 11.6.

13.3 Continuing Calibration Check - refer to section 11.7.

13.4 Method Blank (zero grade air) at 400 cc - refer to section 12.2.

13.5 Blank Spike (BS)) - refer to section 12.3.

13.6 Matrix Duplicate.

13.6.1 One sample is selected at random. Calculate the Relative Percent Difference for all hits.

13.6.2 Evaluate the RPD of target hits versus the limit of 25%. If the RPD does not meet this limit and matrix interference is suspected, no further action is required.

13.7 Surrogate

13.7.1 All blanks, samples, and matrix spikes contain surrogate compounds that are used to monitor method performance. All samples are spiked with 100cc of the internal/surrogate standard that is equivalent to 5ppbv of 4-Bromofluorobenzene.

13.7.2 If the % recovery of 4-Bromofluorobenzene does not meet the control limits generated in house, the recovery must be flagged and:

13.7.2.1 The calculation must be checked.

13.7.2.2 The sample must be reanalyzed to verify recovery of the surrogate is out of control limits due to apparent matrix interference.

13.7.3 If surrogate recoveries are acceptable upon reanalysis, the data from the reanalysis is reported. If the reanalysis date did not meet the hold time, then both sets of data are submitted with the reanalysis reported.

13.7.4 If surrogates are still outside control limits upon reanalysis, then both sets of data must be submitted for confirmation with the first analysis reported.

13.8 Internal Standard.

13.8.1 Retention time for all internal standards must be within  $\pm 0.33$  minutes (20 seconds) of the corresponding internal standard in the latest continuing calibration or 10ppbv standard of initial calibration.

13.8.2 The area (Extracted Ion Current Profile) of the internal standard in all analyses must be within  $\pm 40$  % of the corresponding area in the latest calibration standard (24 hr. time period).

13.8.3 If area of internal standard does not meet control limits, the calculations must be checked. If a problem is not discovered, the sample must be reanalyzed at the same



concentration unless matrix interferences are visibly present in the chromatogram, then a smaller volume is analyzed.

13.8.4 If areas are acceptable upon reanalysis, the reanalysis data is reported.

13.8.5 If areas are unacceptable upon reanalysis, then both sets of data are submitted with the original analysis reported.

## 14.0 CALCULATIONS

### 14.1 Concentration (Conc.)

$$C_x = \frac{A_x C_{is} DF}{A_{is} \overline{RRF}}$$

where:  $C_x$  = Compound concentration, ppbv.

$A_x$  = Area of the characteristic ion for the compound to be measured, counts.

$A_{is}$  = Area of the characteristic ion for the specific internal standard, counts.

$C_{is}$  = Concentration of the internal standard spiking mixture, ppbv

$\overline{RRF}$  = Mean relative response factor from the initial calibration.

DF is the dilution factor as described in 12.6.7

### 14.2 Percent Recovery (% R)

$$\% R = \frac{\text{Concentration found}}{\text{Concentration spiked}} \times 100$$

### 14.3 Relative Percent Difference (RPD)

$$RPD = \frac{|SC - SDC|}{(1/2)(SC + SDC)} \times 100$$

Where: SC = Sample Concentration  
 SDC = Sample Duplicate Concentration

#### 14.4 Relative response factor (RRF)

$$RRF = \frac{A_s \times C_{is}}{A_{is} \times C_s}$$

Where:  $A_s$  = Area of the characteristic ion for the compound being measured.

$A_{is}$  = Area of the characteristic ion for the specific internal standard.

$C_s$  = Concentration of the compound being measured (ppbv).

$C_{is}$  = Concentration of the specific internal standard (ppbv).

#### 14.5 Mean Relative Response Factor

$$\overline{RRF} = \sum_{i=1}^n \frac{x_i}{n}$$

where:

$\overline{RRF}$  = Mean relative response factor.

$x_i$  = RRF of the compound at concentration  $i$ .

$n$  = Number of concentration values, (5 to 7 points in curve).

#### 14.6 Percent relative Standard Deviation (%RSD)

$$\%RSD = \frac{SD_{RRF}}{\overline{RRF}} \times 100$$

and

$$SD_{RRF} = \sqrt{\sum_{i=1}^N \frac{(RRF_i - \overline{RRF})^2}{N - 1}}$$

where:

$SD_{RRF}$  = Standard deviation of initial response factors (per compound).

$RRF_i$  = Relative response factor at a concentration level  $i$ .

$\overline{RRF}$  = Mean of initial relative response factors (per compound).

#### 14.7 Relative Retention Time (RRT)

$$RRT = \frac{RT_c}{RT_{is}}$$

where:  $RT_c$  = Retention time of the target compound, seconds  
 $RT_{is}$  = Retention time of the internal standard, seconds.

#### 14.8 Mean Relative Retention Time

$$\overline{RRT} = \sum_{i=1}^n \frac{RRT}{n}$$

where:  $\overline{RRT}$  = Mean relative retention time for the target compound for each initial calibration standard.  
 $RRT$  = Relative retention time for the target compound at each calibration level.

#### 14.9 Percent Difference (%D)

$$\%D = \frac{RRF_c - \overline{RRF}_i}{\overline{RRF}_i} \times 100$$

where:  $RRF_c$  = RRF of the compound in the continuing calibration standard.  
 $\overline{RRF}_i$  = Mean RRF of the compound in the most recent initial calibration.

### 15.0 DOCUMENTATION

- 15.1 The Analytical Logbooks records the analysis sequence; the logbook must be completed daily. Each instrument has a separate logbook.
  - 15.1.1 If samples require reanalysis, a brief explanation of the reason must be documented in the comment section.
- 15.2 The Standards Preparation Logbook must be completed for all standard preparations. All information must be completed. The page must be signed and dated by the appropriate person.
  - 15.2.1 The SGS Accutest lot number must be cross-referenced on the standard canister.
- 15.3 Instrument Maintenance Logbook must be completed when any type of maintenance is performed on the instrument. Each instrument has a separate log.
- 15.4 Canister Shipping and Receiving Logbook must be completed.

## 16.0 DATA REVIEW & INTERPRETATION

### 16.1 Qualitative identification

- 16.1.1 Analyst shall identify the targeted compounds by comparison of the sample mass spectrum to the mass spectrum of a standard of the suspected compound. The criteria required for a positive identification are:
- 16.1.2 The sample component must elute at the same relative retention time (RRT) as the daily standard. Criteria are the RRT of sample component must be within  $\pm 0.06$  RRT units of the standard.
- 16.1.3 All ions present in the standard mass spectra at a relative intensity greater than 10 % (major abundant ion in the spectrum equals 100 %) must be present in the sample spectrum.
- 16.1.4 The relative intensities of these ions must agree within  $\pm 30$  % between the daily standard and sample spectra. (Example: For an ion with an abundance of 50 % in the standard spectra, the corresponding sample abundance must be between 20 and 80 %. Matrix interferences may skew ion ratios where criteria are exceeded. In this case, analyst's judgment with supervisor's approval is required.
- 16.1.5 Structural isomers (dichlorobenzenes, trimethylbenzenes, and o-xylene) that produce very similar mass spectra are identified as individual isomers if they have sufficiently different GC retention times. Sufficient GC resolution is achieved if the height of the valley between two isomer peaks is less than 25 % of sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs (m,p-xylene).

### 16.2 Quantitative analysis

- 16.2.1 When a target compound has been identified, concentration (see section 16.1) is based on the integrated area of the primary quantitation ion (see Table 4).
- 16.2.2 If the sample produces interference for the primary ion, use a secondary ion to quantitate (see Table 4). This is characterized by an excessive background signal of the same ion, which distorts the peak shape beyond a definitive integration. Also interference could severely inhibit the response of the internal standard ion. If a secondary ion is used for quantitation, new calibration response factors must be generated for this secondary ion.
- 16.2.3 Targets will be reported down to the MDL, with the following exceptions: Methylene chloride, ethanol, hexane, isopropanol, and acetone. These compounds will be reported to the RL in samples, blanks, and canister cert blanks to account for lab background levels.

### 16.3 Library search for tentatively identified compounds.

If a library search is requested, the analyst performs a forward library search of NIST mass spectral library to tentatively identify 15 non-reported compounds. Guidelines for making tentative identification are listed below.

- 16.3.1 These compounds must have a response greater than 10 % of the nearest internal standard. The response is obtained from the integration for peak area of the Total Ion Chromatogram (TIC).
- 16.3.2 The search is to include a spectral printout of the 3 best library matches for a particular substance. The results are to be interpreted by analyst.
- 16.3.3 Molecular ions present in the reference spectrum must be present in the sample spectrum.
- 16.3.4 Relative intensities of major ions in the reference spectrum (ions > 10 % of the most abundant ion) must be present in the sample spectrum.
- 16.3.5 The relative intensities the major ions must agree within  $\pm 20$  %.
- 16.3.6 Ions present in the sample spectrum but not in the reference spectrum are reviewed for possible background contamination or presence of co-eluting compounds.
- 16.3.7 Ions present in the reference spectrum but not in the sample spectrum are verified by performing further manual background subtraction to eliminate the interference created by co-eluting peaks and/or matrix interference.
- 16.3.8 Quantitation of the tentatively identified compounds is obtained from the total ion chromatogram based on a response factor of 1 and is to be tabulated on the library search summary data sheet.
- 16.3.9 Quantitation is performed on the nearest internal standard.

## 17.0 POLLUTION PREVENTION & WASTE MANAGEMENT

- 17.1 Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents, and solvents must be limited to the amounts specified in this SOP. All safety practices designed to limit the escape of vapors, liquids or solids to the environment must be followed. All method users must be familiar with the waste management practices described in section 17.2.
- 17.2 Waste Management. All laboratory waste must be managed, accumulated, and disposed in accordance with all federal or state laws and regulations. Individuals performing this method must follow established waste management procedures as described in the waste management SOP, EHS004. This document describes the proper disposal of all waste materials generated during the testing of samples as follows:



**SGS- DAYTON**  
**STANDARD OPERATING PROCEDURE**

FN: EAT001-32  
Pub. Date: 01/10/1997  
Rev. Date: 09/08/2017  
Page 24 of 36

- 17.2.1 Non hazardous aqueous wastes.
- 17.2.2 Hazardous aqueous wastes
- 17.2.3 Chlorinated organic solvents
- 17.2.4 Non-chlorinated organic solvents
- 17.2.5 Hazardous solid wastes
- 17.2.6 Non-hazardous solid wastes

## **18.0 METHOD AND OTHER SOP REFERENCES**

- 18.1 USEPA METHOD TO-15, 2<sup>nd</sup> edition, 03/18/1999 "Methods for the Determination of Toxic Organic Compounds in Air"
- 18.2 SGS Accutest SOP EAT002 – "Canister Cleaning and Certification SOP"
- 18.3 TO15 NJDEP Low Level

**TABLE 1**

**BFB KEY IONS AND ION ABUNDANCE CRITERIA**

<b>Mass</b>	<b>Ion Abundance Criteria</b>
50	8-40% of mass 95
75	30-66% of mass 95
95	Base peak, 100% relative abundance
96	5-9% of mass 95
173	< 2% of mass 174
174	> 50% and <120% of mass 95
175	4-9% of mass 174
176	>93% and <101% of mass 174
177	5-9% of mass 176

**TABLE 2**

**INTERNAL STANDARD IONS**

<b>Internal Standard</b>	<b>Prim/Sec. Ions</b>
Bromochloromethane	128 / 49, 130, 51
1,4-Difluorobenzene	114 / 63,88
Chlorobenzene-d5	117 / 82, 119

**TABLE 3**  
 OMITTED

**TABLE 4**  
**TARGET COMPOUND IONS**

<b>Analyte</b>	<b>Primary Characteristic Ion</b>	<b>Secondary Characteristic Ion (s)</b>
Acetone	58	43
Benzene	78	77, 52
Benzyl chloride	91	126, 65
1,3-Butadiene	39	54, 53
Bromodichloromethane	83	85, 122
Bromoform	173	175, 254
Bromoethene	106	108, 81
Bromomethane	94	96, 95
Carbon disulfide	76	78, 44
Carbon tetrachloride	117	119, 121
Chlorobenzene	112	77, 114
Cyclohexane	84	56, 69
Chloroethane	64	66, 49
Chloroform	83	85, 47
Chloromethane	50	52, 32
Chlorotrifluoroethene	116	118, 85
3-Chloropropene	76	41, 39, 78
2-Chlorotoluene	91	126, 63
Dibromochloromethane	129	127, 31
1,2-Dibromoethane	107	109, 88
1,2-Dichlorobenzene	146	111, 148
1,3-Dichlorobenzene	146	111, 148
1,4-Dichlorobenzene	146	111, 148
Dichlorodifluoromethane	85	87, 50
1,1-Dichloroethane	63	65, 83
1,2-Dichloroethane	62	64, 98
1,1-Dichloroethene	96	61, 63
cis-1,2-Dichloroethene	96	61, 98
Trans-1,2-Dichloroethene	96	61, 98
1,2-Dichloropropane	63	65
1,4-Dioxane	88	57, 58, 43
cis-1,3-Dichloropropene	75	77, 39
Trans-1,3-Dichloropropene	75	77, 39
Ethanol	45	46, 42
Ethyl Acetate	43	61, 88
4-Ethyltoluene	105	120, 91
Ethylbenzene	91	106, 77
Freon 113	151	101, 103
Freon 114	85	135, 87
Freon 123a	117	67, 85
Hexachlorobutadiene	225	223, 227
Heptane	43	71, 57



**TABLE 4-CONTINUED**  
**TARGET COMPOUND IONS**

<b>Analyte</b>	<b>Primary Characteristic Ion</b>	<b>Secondary Characteristic Ion (s)</b>
Hexane	57	47, 41
2-Hexanone	43	58,100
Isopropyl Alcohol	45	43, 59
Methyl-t-butyl ether	73	57,43
Methylene chloride	84	86,49
Methyl ethyl ketone	72	43, 57
Propylene	41	39, 42
Styrene	104	78, 103
Tetrahydrofuran	42	71, 72
1,2,4-Trichlorobenzene	180	182, 145
1,1,2,2-Tetrachloroethane	83	85, 131
Tetrachloroethene	164	129, 131, 166
Toluene	92	91, 65
1,1,1-Trichloroethane	97	99, 61
1,1,2-Trichloroethane	83	97, 85
Trichloroethene	95	97, 130, 132
Trichlorofluoromethane	101	103, 105
1,2,4-Trimethylbenzene	105	120, 119
1,3,5-Trimethylbenzene	105	120, 119
2,2,4-Trimethylpentane	57	56, 99
Vinyl acetate	43	86, 44
Vinyl chloride	62	64, 61
o-Xylene	106	91, 77
m-Xylene	106	91, 77
p-Xylene	106	91, 77
Pentane (1)	42	41, 57
Nonane (1)	43	71, 128
Isopropylbenzene(Cumene)	105	120, 77
Tertiary Butyl Alcohol	59	41, 43
Naphthalene	128	127,129
Acrylonitrile	52	53
Acetonitrile	41	40
n-Butylbenzene	134	91
n-Propylbenzene	120	105
1,1,1,2 Tetrachloroethane	131	95
Total Volatiles as Pentane	Total Peak Area	
Total Volatiles as Heptane	Total Peak Area	
Sec-Butylbenzene	134	105

(1) NELAC accreditation is not offered for this compound.

**TABLE 5**  
**REPORTING LIMITS**

Compound	TO15 Canister RDL(ppb v)
Propylene	0.5
Freon-12 (Dichlorodifluoromethane)	0.2
Chloromethane	0.2
Freon-114	0.2
Vinyl Chloride	0.2
1,3-Butadiene	0.2
Bromomethane	0.2
Chloroethane	0.2
Carbon Disulfide	0.2
Ethanol	0.5
Acetone	0.2
Freon-11 (Trichlorofluoromethane)	0.2
Isopropyl Alcohol	0.2
1,1-Dichloroethene	0.2
Methylene Chloride	0.2
Freon-113	0.2
Trans-1,2-Dichloroethene	0.2
1,1-Dichloroethane	0.2
Methyl Tertiary Butyl Ether	0.2
Tetrahydrofuran	0.2
Methyl Ethyl Ketone (2- Butanone)	0.2
Cis-1,2-Dichloroethene	0.2
Hexane	0.2
Chloroform	0.2
Ethyl Acetate	0.2
Vinyl Acetate	0.2
1,2-Dichloroethane	0.2
1,1,1-Trichloroethane	0.2
Benzene	0.2
Carbon Tetrachloride	0.2
Cyclohexane	0.2
1,2-Dichloropropane	0.2
Trichloroethylene	0.04
Bromodichloromethane	0.2
1,4-Dioxane	0.2

**TABLE 5 (CONT'D)**

Compound	TO15 Canister RDL(ppb v)
Heptane	0.2
Cis-1,3-Dichloropropene	0.2
Trans-1,3-Dichloropropene	0.2
1,1,2-Trichloroethane	0.2
Toluene	0.2
Methyl IsoButyl Ketone (2-Hexanone)	0.2
Dibromochloromethane	0.2
1,2-Dibromomethane (EDB)	0.2
Tetrachloroethylene	0.04
Chlorobenzene	0.2
Ethylbenzene	0.2
M,p-Xylene	0.2
o-xylene	0.2
1,1,2,2-Tetrachloroethane	0.2
Bromoform	0.2
Styrene	0.2
4-Ethyltoluene	0.2
1,3,5-Trimethylbenzene	0.2
1,2,4-Trimethylbenzene	0.2
1,3-Dichlorobenzene(m)	0.2
1,4-Dichlorobenzene(p)	0.2
1,2-Dichlorobenzene(o)	0.2
Benzyl Chloride (a-Chlorotoluene)	0.2
1,2,4-Trichlorobenzene	0.2
Hexachloro-1,3-butadiene	0.2
Bromoethene	0.2
3-Chloropropene	0.2
2-Chlorotoluene	0.2
2,2,4-Trimethylpentane	0.2
Pentane	0.2

**TABLE 5 (CONT'D)**

Compound	TO15 Canister RDL(ppb v)
Nonane	0.2
Isopropylbenzene(Cumene)	0.2
Tertiary Butyl Alcohol	0.2
Naphthalene	0.2
Total Volatiles as Pentane	10
Total Volatiles as Heptane	10
Acrylonitrile	0.2
Acetonitrile	0.2
n-Butylbenzene	0.2
n-Propylbenzene	0.2
1,1,2,2-Tetrachloroethane	0.2
Freon 123a	0.2
Chlorotrifluoroethene	0.2
Sec-Butylbenzene	0.2

**TABLE 6**

CANISTER PRESSURIZATION CALCULATIONS												
CANISTER PRESSURE RECEIVED					CANISTER FINAL PRESSURE				DILUTION		SAMPLING	
"Hg (vac)	"Hg	Atm	psia	Vol (L)	"Hg	psia	Vol. (L)	psig		Factor	Volume (cc)	
0.0	29.92	1.00	14.7	6.0	29.92	14.7	6.0	0.0		1	400	
0.5	29.42	0.98	14.5	5.9	29.42	14.5	5.9	-0.2		1	400	
1.0	28.92	0.97	14.2	5.8	28.92	14.2	5.8	-0.5		1	400	
1.5	28.42	0.95	14.0	5.7	28.42	14.0	5.7	-0.7		1	400	
2.0	27.92	0.93	13.7	5.6	27.92	13.7	5.6	-1.0		1	400	
2.5	27.42	0.92	13.5	5.5	27.42	13.5	5.5	-1.2		1	400	
3.0	26.92	0.90	13.2	5.4	26.92	13.2	5.4	-1.5		1	400	
3.5	26.42	0.88	13.0	5.3	26.42	13.0	5.3	-1.7		1	400	
4.0	25.92	0.87	12.7	5.2	25.92	12.7	5.2	-2.0		1	400	
4.5	25.42	0.85	12.5	5.1	25.42	12.5	5.1	-2.2		1	400	
5.0	24.92	0.83	12.2	5.0	24.92	12.2	5.0	-2.5		1	400	
5.5	24.42	0.82	12.0	4.9	24.42	12.0	4.9	-2.7		1	400	
6.0	23.92	0.80	11.7	4.8	23.92	11.7	4.8	-3.0		1	400	
6.5	23.42	0.78	11.5	4.7	23.42	11.5	4.7	-3.2		1	400	
7.0	22.92	0.77	11.3	4.6	22.92	11.3	4.6	-3.4		1	400	
7.5	22.42	0.75	11.0	4.5	22.42	11.0	4.5	-3.7		1	400	"Hg(vac)
8.0	21.92	0.73	10.8	4.4	32.33	15.9	6.5	1.2		1.48	590	8.0
8.5	21.42	0.72	10.5	4.3	32.67	16.0	6.5	1.3		1.53	610	8.5
9.0	20.92	0.70	10.3	4.2	32.43	15.9	6.5	1.2		1.55	620	9.0
9.5	20.42	0.68	10.0	4.1	32.16	15.8	6.4	1.1		1.58	630	9.5
10.0	19.92	0.67	9.8	4.0	31.87	15.7	6.4	1.0		1.60	640	10.0
10.5	19.42	0.65	9.5	3.9	32.04	15.7	6.4	1.0		1.65	660	10.5
11.0	18.92	0.63	9.3	3.8	32.16	15.8	6.4	1.1		1.70	680	11.0
11.5	18.42	0.62	9.0	3.7	32.24	15.8	6.5	1.1		1.75	700	11.5
12.0	17.92	0.60	8.8	3.6	32.26	15.8	6.5	1.1		1.80	720	12.0
12.5	17.42	0.58	8.6	3.5	32.23	15.8	6.5	1.1		1.85	740	12.5
13.0	16.92	0.57	8.3	3.4	32.15	15.8	6.4	1.1		1.90	760	13.0
13.5	16.42	0.55	8.1	3.3	32.02	15.7	6.4	1.0		1.95	780	13.5
14.0	15.92	0.53	7.8	3.2	32.64	16.0	6.5	1.3		2.05	820	14.0
14.5	15.42	0.52	7.6	3.1	32.38	15.9	6.5	1.2		2.10	840	14.5
15.0	14.92	0.50	7.3	3.0	32.08	15.8	6.4	1.1		2.15	860	15.0

**Note:** Dilution factors are typically compensated for by concentrating more sample volume.

Calculations:      psia(rec) x DF = psia(final)

psia(final) - 14.7 = psig(final)

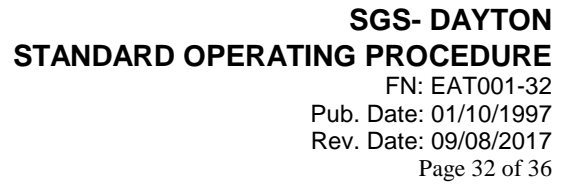
This results in a quantitation factor of 1.

DF x Volume(rec) = Volume(final) in cc

DF x 400 = Volume(cc) introduced into concentrator for a quant factor of 1

### Conversion Equivalents

0"Hg(vac) = 29.9"Hg = 1atm = 14.7psia = 0psig



## CANISTER SECONDARY DILUTION LOG

[illegible]

**TABLE 8**

**SECONDARY DILUTION CONVERSION CHART FOR 6-LITER CANISTERS**

INITIAL				FINAL				INITIAL				FINAL			
"Hg (vac)	"Hg	Psia	Vol. (L)	psi a	psi g	Vol (L)	DF	"Hg (vac)	"Hg	psia	Vol. (L)	psi a	psi g	Vol (L)	DF
0.0	29.9	14.7	6.0	15.4	0.7	6.30	1.05	7.6	22.3	11.0	4.5	15.9	1.2	6.49	1.45
0.2	29.7	14.6	6.0	15.3	0.6	6.26	1.05	7.8	22.1	10.9	4.4	15.8	1.1	6.43	1.45
0.4	29.5	14.5	5.9	15.2	0.5	6.21	1.05	8.0	21.9	10.8	4.4	15.6	0.9	6.37	1.45
0.6	29.3	14.4	5.9	15.8	1.1	6.47	1.10	8.2	21.7	10.7	4.4	15.5	0.8	6.31	1.45
0.8	29.1	14.3	5.8	15.7	1.0	6.42	1.10	8.4	21.5	10.6	4.3	15.9	1.2	6.47	1.50
1.0	28.9	14.2	5.8	15.6	0.9	6.38	1.10	8.6	21.3	10.5	4.3	15.7	1.0	6.41	1.50
1.2	28.7	14.1	5.8	15.5	0.8	6.33	1.10	8.8	21.1	10.4	4.2	15.6	0.9	6.35	1.50
1.4	28.5	14.0	5.7	15.4	0.7	6.29	1.10	9.0	20.9	10.3	4.2	15.9	1.2	6.50	1.55
1.6	28.3	13.9	5.7	15.3	0.6	6.25	1.10	9.2	20.7	10.2	4.2	15.8	1.1	6.44	1.55
1.8	28.1	13.8	5.6	15.9	1.2	6.48	1.15	9.4	20.5	10.1	4.1	15.6	0.9	6.38	1.55
2.0	27.9	13.7	5.6	15.8	1.1	6.44	1.15	9.6	20.3	10.0	4.1	15.5	0.8	6.31	1.55
2.2	27.7	13.6	5.6	15.7	1.0	6.39	1.15	9.8	20.1	9.9	4.0	15.8	1.1	6.45	1.60
2.4	27.5	13.5	5.5	15.5	0.8	6.35	1.15	10.0	19.9	9.8	4.0	15.7	1.0	6.39	1.60
2.6	27.3	13.4	5.5	15.4	0.7	6.30	1.15	10.2	19.7	9.7	4.0	15.5	0.8	6.33	1.60
2.8	27.1	13.3	5.4	15.3	0.6	6.25	1.15	10.4	19.5	9.6	3.9	15.8	1.1	6.46	1.65
3.0	26.9	13.2	5.4	15.9	1.2	6.48	1.20	10.6	19.3	9.5	3.9	15.7	1.0	6.39	1.65
3.2	26.7	13.1	5.4	15.7	1.0	6.43	1.20	10.8	19.1	9.4	3.8	15.5	0.8	6.33	1.65
3.4	26.5	13.0	5.3	15.6	0.9	6.38	1.20	11.0	18.9	9.3	3.8	15.8	1.1	6.45	1.70
3.6	26.3	12.9	5.3	15.5	0.8	6.33	1.20	11.2	18.7	9.2	3.8	15.6	0.9	6.38	1.70
3.8	26.1	12.8	5.2	15.4	0.7	6.28	1.20	11.4	18.5	9.1	3.7	15.9	1.2	6.50	1.75
4.0	25.9	12.7	5.2	15.9	1.2	6.50	1.25	11.6	18.3	9.0	3.7	15.7	1.0	6.43	1.75
4.2	25.7	12.6	5.2	15.8	1.1	6.45	1.25	11.8	18.1	8.9	3.6	15.6	0.9	6.36	1.75
4.4	25.5	12.5	5.1	15.7	1.0	6.40	1.25	12.0	17.9	8.8	3.6	15.8	1.1	6.47	1.80
4.6	25.3	12.4	5.1	15.5	0.8	6.35	1.25	12.2	17.7	8.7	3.6	15.7	1.0	6.39	1.80
4.8	25.1	12.3	5.0	15.4	0.7	6.30	1.25	12.4	17.5	8.6	3.5	15.9	1.2	6.50	1.85
5.0	24.9	12.2	5.0	15.9	1.2	6.50	1.30	12.6	17.3	8.5	3.5	15.7	1.0	6.42	1.85
5.2	24.7	12.1	5.0	15.8	1.1	6.44	1.30	12.8	17.1	8.4	3.4	15.6	0.9	6.35	1.85
5.4	24.5	12.0	4.9	15.7	1.0	6.39	1.30	13.0	16.9	8.3	3.4	15.8	1.1	6.45	1.90
5.6	24.3	11.9	4.9	15.5	0.8	6.34	1.30	13.2	16.7	8.2	3.4	15.6	0.9	6.37	1.90
5.8	24.1	11.8	4.8	15.4	0.7	6.29	1.30	13.4	16.5	8.1	3.3	15.8	1.1	6.46	1.95
6.0	23.9	11.7	4.8	15.9	1.2	6.47	1.35	13.6	16.3	8.0	3.3	15.6	0.9	6.38	1.95
6.2	23.7	11.7	4.8	15.7	1.0	6.42	1.35	13.8	16.1	7.9	3.2	15.8	1.1	6.46	2.00
6.4	23.5	11.6	4.7	15.6	0.9	6.37	1.35	14.0	15.9	7.8	3.2	15.6	0.9	6.38	2.00
6.6	23.3	11.5	4.7	15.5	0.8	6.31	1.35	14.2	15.7	7.7	3.2	15.4	0.7	6.30	2.00
6.8	23.1	11.4	4.6	15.9	1.2	6.49	1.40	14.4	15.5	7.6	3.1	15.2	0.5	6.22	2.00
7.0	22.9	11.3	4.6	15.8	1.1	6.43	1.40	14.6	15.3	7.5	3.1	15.1	0.4	6.14	2.00
7.2	22.7	11.2	4.6	15.6	0.9	6.38	1.40	14.8	15.1	7.4	3.0	14.9	0.2	6.06	2.00
7.4	22.5	11.1	4.5	15.5	0.8	6.32	1.40	15.0	14.9	7.3	3.0	14.7	0.0	5.98	2.00

**Calculations:** Psia(rec) x DF = psia(final)  
 Psia(final) - 14.7 = psig(final)

**Conversion Equivalents**

0"Hg(vac) = 29.9"Hg = 1atm = 14.7psia = 0psig





**TABLE 10 A**  
**FLOW CONTROLLER**  
**CALIBRATION TABLE**  
**80% CAPACITY**

Restrictor Type	Restrictor Orifice ID (inches)	Sampling Time	6-Liter Canister Flow Rate (CC/MIN)	1-Liter Canister Flow Rate (CC/MIN)
#1	0.0080	5 Minutes	NA	167.0
#1	0.0080	30 Minutes	167.0	26.7
#1	0.0080	1 Hour	83.0	13.3
#2	0.0050	2 Hour	41.0	6.7
#2	0.0050	3 Hour	27.7	4.4
#2	0.0050	4 Hour	20.8	3.4
#3	0.0035	6 Hour	13.8	NA
#3	0.0035	8 Hour	10.4	NA
#3	0.0035	12 Hour	6.9	NA
#4	0.0020	24 Hour	3.4	NA

**TABLE 10 B**  
**FLOW CONTROLLER**  
**CALIBRATION TABLE**  
**90% CAPACITY**

Restrictor Type	Restrictor Orifice ID (inches)	Sampling Time	6-Liter Canister Flow Rate (CC/MIN)	1-Liter Canister Flow Rate (CC/MIN)
#1	0.0080	5 Minutes	NA	180.0
#1	0.0080	30 Minutes	180.0	30.0
#1	0.0080	1 Hour	90.0	15.0
#2	0.0050	2 Hour	45.0	7.5
#2	0.0050	3 Hour	30.0	5.0
#2	0.0050	4 Hour	22.5	3.8
#3	0.0035	6 Hour	15.0	NA
#3	0.0035	8 Hour	11.3	NA
#3	0.0035	12 Hour	7.5	NA
#4	0.0020	24 Hour	3.8	NA

**APPENDIX B:**

**SAMP Update Pages**

## 2.0 SAMPLE TRACKING SYSTEM

Sample identification will follow an alpha-numeric code that will uniquely identify each sample by the matrix sampled, site location number, sequential sample number and depth interval, as appropriate. Matrix sampled will be identified by a two letter code, (i.e., MW for monitoring well groundwater samples). Sequential sample numbers at each new sampling location for each sample type will begin with 01 and will increase accordingly. Sample designations for soil samples collected will include the sample depth.

The following is a guide for sample identification:

Matrix and SWMU #	Sequential Sample Location	Sample Interval Depth (in feet - if applicable) (N-N)
AANN	- AANN	

where:

A	=	alphabetic
N	=	numeric

Matrix codes for this project will be as follows:

SB	=	Soil sample from soil boring location
MW	=	Monitoring well groundwater
GW	=	Groundwater sample from Geoprobe®
SG	=	Soil gas sample
IA	=	Indoor air sample
OA	=	Outdoor air sample
EB	=	Equipment blank
TB	=	Trip blank

Example sample designations are shown below:

- Soil samples collected from the first boring at SWMU 2 and collected at a depth of 0 to 2 ft bgs will be labeled as SB02-01 (0-2).
- Groundwater samples collected from soil boring SB-14 will SB14-01.

- Groundwater samples collected from existing monitoring well MW-53 will be labeled as MW53-01.
- The first soil gas, indoor air, and outdoor air samples will be SV-01, IA-01, and OA-01, respectively.

surveyor will complete the physical survey. The sample locations will be marked with wooden stakes or plastic pin flags during the sampling process. Horizontal coordinates will be referenced to the state planar or Geodetic System Grid coordinate system. Elevations will be referenced to mean sea level. Vertical controls will be established to the nearest 0.01- foot. Horizontal controls will be established to the nearest 0.10-foot. The horizontal survey control will reference State Plane coordinate system and the vertical survey control will reference the North American Vertical Datum (NAVD 1988).

### **3.8 SOIL GAS, INDOOR AIR, AND OUTDOOR AIR SAMPLING**

Refer to SOP No. S-17 in Appendix A of the QAPP.

## **APPENDIX C:**

### **HASP Update Pages**

# SITE-SPECIFIC HEALTH & SAFETY PLAN

HONEYWELL  
DELAWARE VALLEY WORKS  
CLAYMONT, DELAWARE



Project Number:

7772180021

Prepared by:

**Wood Environment & Infrastructure Solutions, Inc.**  
751 Arbor Way, Suite 180  
Blue Bell, PA 19422



July 2018







## 1.0 SITE DESCRIPTION

The Honeywell Claymont facility is located on an approximately 36 acre parcel at 6100 Philadelphia Pike in New Castle County, Claymont, DE. Honeywell purchased the property in 1954 from the James River Plantation Farm. The DVW has been an industrial facility for nearly 100 years. Over its history, the DVW manufactured various chemical products including pesticides (DDT and TDE), organic and inorganic acids, and specialty chemicals. Currently, the DVW produces two materials: boron trifluoride (BF<sub>3</sub>), a reaction catalyst used in a variety of process applications, and fluosulfonic acid. There are 14 solid waste management units (SWMU) and two areas of concern (AOC) located at the North Plant, see *Figure 1-1 Site Plan* below.

The following tasks are to be performed at the site:

AMEC Foster Wheeler	Sub	Tasks	AHA Developed	Initial Level of PPE
<input checked="" type="checkbox"/>	<input type="checkbox"/>	▪ Hollow Stem Auger Drilling	<input checked="" type="checkbox"/>	D
<input type="checkbox"/>	<input checked="" type="checkbox"/>	▪ Cone Penetrometer Testing / Direct Push Drilling	<input checked="" type="checkbox"/>	D
<input type="checkbox"/>	<input checked="" type="checkbox"/>	▪ Shelby Tube Soil Sampling	<input checked="" type="checkbox"/>	D
<input type="checkbox"/>	<input checked="" type="checkbox"/>	▪ Monitor Well Installation and Development	<input checked="" type="checkbox"/>	D
<input checked="" type="checkbox"/>	<input type="checkbox"/>	▪ Groundwater Sampling	<input checked="" type="checkbox"/>	D
<input checked="" type="checkbox"/>	<input type="checkbox"/>	▪ Subslab Sampling	<input checked="" type="checkbox"/>	D
<input checked="" type="checkbox"/>	<input type="checkbox"/>	▪ Indoor Air Sampling	<input checked="" type="checkbox"/>	D

Expected start date: TBD

Expected duration of project: 4 weeks

Expected average number of workers on site per day: 5-6

TABLE 3.1

## TRAINING/MEDICAL SURVEILLANCE/RESPIRATORY PROTECTION RECORDS

Role:	Required?	Names of Field Team Members					
		Field Operations Lead/SHSO: TBD	Rachel Fein	Zachary Schwarz			
Training/Medical		Dates	Dates	Dates	Dates	Dates	Dates
Medical Surveillance	X		6/19/15	12/29/14			
40-Hour Initial	X		03/01/2001	05/25/2007			
8-Hour Supervisor <sup>1</sup>	X			06/03/2013			
8-Hour Refresher	X		07/29/2014	01/28/2015			
First Aid <sup>1,2</sup>	X		10/19/2012	10/19/2012			
CPR <sup>1,2</sup>	X		10/19/14	10/19/2012			
Hazard Communication	X		07/29/14	07/29/14			
Drilling Safety			09/03/2010	3/2015			

<sup>1</sup> If Applicable<sup>2</sup> At least one worker must be trained in First Aid/CPR<sup>3</sup> Required if acting as LF or SSHO

## **APPENDIX D:**

### **VISL Outputs**

## Site-specific VISL Results

### Commercial Equation Inputs

1

\* Inputted values different from Commercial defaults are highlighted.  
Output generated 25JUL2018:14:37:20

Variable	Commercial Air Default Value	Value
AF <sub>gw</sub> (Attenuation Factor Groundwater) unitless	0.001	0.001
AF <sub>ss</sub> (Attenuation Factor Sub-Slab) unitless	0.03	0.03
AT <sub>w</sub> (averaging time - composite worker)	365	365
ED <sub>w</sub> (exposure duration - composite worker) yr	25	25
EF <sub>w</sub> (exposure frequency - composite worker) day/yr	250	250
ET <sub>w</sub> (exposure time - composite worker) hr	8	8
THQ (target hazard quotient) unitless	0.1	0.1
LT (lifetime) yr	70	70
TR (target risk) unitless	1.0E-06	1.0E-06

Output generated 25JUL2018:14:37:20

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Soil Source? ( $C_{vp} > C_{ia}, Target?$ )	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Groundwater Source? ( $C_{hc} > C_{ia}, Target?$ )	Target Indoor Air Concentration (TCR=1E-06 or THQ=0.1) $MIN(C_{ia,c}, C_{ia,nc})$ ( $\mu g/m^3$ )	Toxicity Basis
Benzene	71-43-2	Yes	Yes	Yes	Yes	1.57E+00	CA
Chlorobenzene	108-90-7	Yes	Yes	Yes	Yes	2.19E+01	NC
Dichloroethylene, 1,2-cis-	156-59-2	Yes	No	No Inhal. Tox. Info	No Inhal. Tox. Info		
Tetrachloroethylene	127-18-4	Yes	Yes	Yes	Yes	1.75E+01	NC
Trichloroethylene	79-01-6	Yes	Yes	Yes	Yes	8.76E-01	NC

Chemical	Target Sub-Slab and Near-source Soil Gas Concentration (TCR=1E-06 or THQ=0.1) $C_{sg}, Target$ ( $\mu g/m^3$ )	Target Groundwater Concentration (TCR=1E-06 or THQ=0.1) $C_{gw}, Target$ ( $\mu g/L$ )	Is Target Groundwater Concentration < MCL? ( $C_{gw} < MCL?$ )	Pure Phase Vapor Concentration $C_{vp}$ (25 °C) ( $\mu g/m^3$ )	Maximum Groundwater Vapor Concentration $C_{hc}$ ( $\mu g/m^3$ )	Temperature for Maximum Groundwater Vapor Concentration (°C)
Benzene	5.24E+01	6.93E+00	No (5)	3.98E+08	4.06E+08	25
Chlorobenzene	7.30E+02	1.72E+02	No (100)	7.25E+07	6.33E+07	25
Dichloroethylene, 1,2-cis-				1.04E+09	1.07E+09	25
Tetrachloroethylene	5.84E+02	2.42E+01	No (5)	1.65E+08	1.49E+08	25
Trichloroethylene	2.92E+01	2.18E+00	Yes (5)	4.88E+08	5.15E+08	25

Chemical	Lower Explosive Limit LEL (% by volume)	LEL Ref	Inhalation Unit Risk ( $ug/m^3$ ) <sup>-1</sup>	IUR Ref	RfC (mg/m <sup>3</sup> )	RfC Ref	Mutagenic Indicator	Carcinogenic VISL TCR=1E-06 $C_{ia,c}$ ( $\mu g/m^3$ )	Noncarcinogenic VISL THQ=0.1 $C_{ia,nc}$ ( $\mu g/m^3$ )
Benzene	1.20	CRC89	7.80E-06	I	3.00E-02	I	No	1.57E+00	1.31E+01
Chlorobenzene	1.30	CRC89			5.00E-02	P	No		2.19E+01
Dichloroethylene, 1,2-cis-	3.00	CRC89					No		
Tetrachloroethylene			2.60E-07	I	4.00E-02	I	No	4.72E+01	1.75E+01
Trichloroethylene	8.00	CRC89	4.10E-06	I	2.00E-03	I	Mut	2.99E+00	8.76E-01

Chemical	CAS Number	Site Groundwater Concentration $C_{gw}$ ( $\mu\text{g/L}$ )	Site Indoor Air Concentration $C_{ia}$ ( $\mu\text{g/m}^3$ )	VI Carcinogenic Risk CR	VI Hazard HQ
Benzene	71-43-2	0.8	1.82E-01	1.15E-07	1.38E-03
Chlorobenzene	108-90-7	80	1.02E+01		4.64E-02
Dichloroethylene, 1,2-cis-	156-59-2	0.1			
Tetrachloroethylene	127-18-4	4.1	2.97E+00	6.29E-08	1.69E-02
Trichloroethylene	79-01-6	0.4	1.61E-01	5.39E-08	1.84E-02
<i>*Sum</i>				2.32E-07	8.31E-02

Chemical	Inhalation Unit Risk ( $\mu\text{g/m}^3$ ) <sup>-1</sup>	IUR Ref	Chronic RfC ( $\text{mg/m}^3$ )	RfC Ref	Temperature (°C)\ for Groundwater Vapor Concentration	Mutagen?
Benzene	7.80E-06	I	3.00E-02	IRIS	25	No
Chlorobenzene			5.00E-02	PPRTV	25	No
Dichloroethylene, 1,2-cis-					25	No
Tetrachloroethylene	2.60E-07	I	4.00E-02	IRIS	25	No
Trichloroethylene	4.10E-06	I	2.00E-03	IRIS	25	Mut
<i>*Sum</i>						

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	MW	MW Ref	Vapor Pressure VP (mm Hg)	VP Ref	S (mg/L)	S Ref
Benzene	71-43-2	Yes	Yes	78.12	PHYSPROP	9.48E+01	PHYSPROP	1.79E+03	PHYSPROP
Chlorobenzene	108-90-7	Yes	Yes	112.56	PHYSPROP	1.20E+01	PHYSPROP	4.98E+02	PHYSPROP
Dichloroethylene, 1,2-cis-	156-59-2	Yes	No	96.94	PHYSPROP	2.00E+02	PHYSPROP	6.41E+03	PHYSPROP
Tetrachloroethylene	127-18-4	Yes	Yes	165.83	PHYSPROP	1.85E+01	PHYSPROP	2.06E+02	PHYSPROP
Trichloroethylene	79-01-6	Yes	Yes	131.39	PHYSPROP	6.90E+01	PHYSPROP	1.28E+03	PHYSPROP

Chemical	MCL (ug/L)	HLC (atm-m³/mole)	Henry's Law Constant (unitless)	H` and HLC Ref	Henry's Law Constant Used in Calcs (unitless)	D <sub>ia</sub> \ (cm²/s)	D <sub>ia</sub> \ Ref	D <sub>iw</sub> \ (cm²/s)	D <sub>iw</sub> \ Ref	Normal Boiling Point T <sub>boil</sub> \ (K)
Benzene	5	5.55E-03	2.27E-01	PHYSPROP	2.27E-01	8.95E-02	WATER9 (U.S. EPA, 2001)	1.03E-05	WATER9 (U.S. EPA, 2001)	353.15
Chlorobenzene	100	3.11E-03	1.27E-01	PHYSPROP	1.27E-01	7.21E-02	WATER9 (U.S. EPA, 2001)	9.48E-06	WATER9 (U.S. EPA, 2001)	404.85
Dichloroethylene, 1,2-cis-	70	4.08E-03	1.67E-01	PHYSPROP	1.67E-01	8.84E-02	WATER9 (U.S. EPA, 2001)	1.13E-05	WATER9 (U.S. EPA, 2001)	333.25
Tetrachloroethylene	5	1.77E-02	7.24E-01	PHYSPROP	7.24E-01	5.05E-02	WATER9 (U.S. EPA, 2001)	9.46E-06	WATER9 (U.S. EPA, 2001)	394.45
Trichloroethylene	5	9.85E-03	4.03E-01	PHYSPROP	4.03E-01	6.87E-02	WATER9 (U.S. EPA, 2001)	1.02E-05	WATER9 (U.S. EPA, 2001)	360.35



Chemical	BP Ref	Critical Temperature $T_{crit}$ \\\n(K)	$T_{crit}$ \\\nRef	Enthalpy of vaporization at the normal boiling point $\Delta H_{v,b}$ \\\n(cal/mol)	$\Delta H_{v,b}$ \\\nRef	$K_{oc}$ \\\n(cm <sup>3</sup> /g)	$K_{oc}$ \\\nRef	Lower Explosive Limit LEL (% by volume)	LEL Ref
Benzene	PHYSPROP	5.62E+02	CRC89	7342.26	CRC89	145.8	EPI	1.20	CRC89
Chlorobenzene	PHYSPROP	6.32E+02	CRC89	8410.61	CRC89	233.9	EPI	1.30	CRC89
Dichloroethylene, 1,2-cis-	PHYSPROP	5.36E+02	CRC89	7217.97	CRC89	39.6	EPI	3.00	CRC89
Tetrachloroethylene	PHYSPROP	6.20E+02	YAWS	8288.00	Weast	94.94	EPI		
Trichloroethylene	PHYSPROP	5.71E+02	YAWS	7505.00	Weast	60.7	EPI	8.00	CRC89

## Site-specific VISL Results

### Commercial Equation Inputs

1

\* Inputted values different from Commercial defaults are highlighted.  
Output generated 25JUL2018:15:53:31

Variable	Commercial Air Default Value	Value
AF <sub>gw</sub> (Attenuation Factor Groundwater) unitless	0.001	0.001
AF <sub>ss</sub> (Attenuation Factor Sub-Slab) unitless	0.03	0.03
AT <sub>w</sub> (averaging time - composite worker)	365	365
ED <sub>w</sub> (exposure duration - composite worker) yr	25	25
EF <sub>w</sub> (exposure frequency - composite worker) day/yr	250	250
ET <sub>w</sub> (exposure time - composite worker) hr	8	8
THQ (target hazard quotient) unitless	0.1	0.1
LT (lifetime) yr	70	70
TR (target risk) unitless	1.0E-06	1.0E-06

Output generated 25JUL2018:15:53:31

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Soil Source? ( $C_{vp} > C_{ia, Target?}$ )	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Groundwater Source? ( $C_{hc} > C_{ia, Target?}$ )	Target Indoor Air Concentration (TCR=1E-06 or THQ=0.1) $MIN(C_{ia,c}, C_{ia,nc})$ ( $\mu g/m^3$ )	Toxicity Basis
Acetone	67-64-1	Yes	Yes	Yes	Yes	1.35E+04	NC
Benzene	71-43-2	Yes	Yes	Yes	Yes	1.57E+00	CA
Carbon Disulfide	75-15-0	Yes	Yes	Yes	Yes	3.07E+02	NC
Chlorobenzene	108-90-7	Yes	Yes	Yes	Yes	2.19E+01	NC
Chloroform	67-66-3	Yes	Yes	Yes	Yes	5.33E-01	CA
Dichlorobenzene, 1,2-	95-50-1	Yes	Yes	Yes	Yes	8.76E+01	NC
Dichlorobenzene, 1,4-	106-46-7	Yes	Yes	Yes	Yes	1.11E+00	CA
Dichloroethylene, 1,1-	75-35-4	Yes	Yes	Yes	Yes	8.76E+01	NC
Dichloroethylene, 1,2-cis-	156-59-2	Yes	No	No Inhal. Tox. Info	No Inhal. Tox. Info		
Dichloroethylene, 1,2-trans-	156-60-5	Yes	No	No Inhal. Tox. Info	No Inhal. Tox. Info		
Ethylbenzene	100-41-4	Yes	Yes	Yes	Yes	4.91E+00	CA
Methyl Ethyl Ketone (2-Butanone)	78-93-3	Yes	Yes	Yes	Yes	2.19E+03	NC
Naphthalene	91-20-3	Yes	Yes	Yes	Yes	3.61E-01	CA
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	Yes	Yes	Yes	Yes	2.19E+03	NC
Trichloroethylene	79-01-6	Yes	Yes	Yes	Yes	8.76E-01	NC
Vinyl Chloride	75-01-4	Yes	Yes	Yes	Yes	2.79E+00	CA

Output generated 25JUL2018:15:53:31

Chemical	Target Sub-Slab and Near-source Soil Gas Concentration (TCR=1E-06 or THQ=0.1) $C_{sg,Target}$ ( $\mu\text{g}/\text{m}^3$ )	Target Groundwater Concentration (TCR=1E-06 or THQ=0.1) $C_{gw,Target}$ ( $\mu\text{g}/\text{L}$ )	Is Target Groundwater Concentration < MCL? ( $C_{gw} < \text{MCL}$ ?)	Pure Phase Vapor Concentration $C_{vp}$ ( $25^\circ\text{C}$ ) ( $\mu\text{g}/\text{m}^3$ )	Maximum Groundwater Vapor Concentration $C_{hc}$ ( $\mu\text{g}/\text{m}^3$ )	Temperature for Maximum Groundwater Vapor Concentration ( $^\circ\text{C}$ )
Acetone	4.51E+05	9.45E+06	--	7.23E+08	1.43E+09	25
Benzene	5.24E+01	6.93E+00	No (5)	3.98E+08	4.06E+08	25
Carbon Disulfide	1.02E+04	5.21E+02	--	1.47E+09	1.27E+09	25
Chlorobenzene	7.30E+02	1.72E+02	No (100)	7.25E+07	6.33E+07	25
Chloroform	1.78E+01	3.55E+00	Yes (80)	1.26E+09	1.19E+09	25
Dichlorobenzene, 1,2-	2.92E+03	1.12E+03	No (600)	1.08E+07	1.22E+07	25
Dichlorobenzene, 1,4-	3.72E+01	1.13E+01	Yes (75)	1.38E+07	8.01E+06	25
Dichloroethylene, 1,1-	2.92E+03	8.21E+01	No (7)	3.13E+09	2.58E+09	25
Dichloroethylene, 1,2-cis-				1.04E+09	1.07E+09	25
Dichloroethylene, 1,2-trans-				1.73E+09	1.73E+09	25
Ethylbenzene	1.64E+02	1.52E+01	Yes (700)	5.48E+07	5.44E+07	25
Methyl Ethyl Ketone (2-Butanone)	7.30E+04	9.41E+05	--	3.51E+08	5.19E+08	25
Naphthalene	1.20E+01	2.01E+01	--	5.86E+05	5.58E+05	25
Trichloro-1,2,2-trifluoroethane, 1,1,2-	7.30E+04	1.02E+02	--	3.65E+09	3.66E+09	25
Trichloroethylene	2.92E+01	2.18E+00	Yes (5)	4.88E+08	5.15E+08	25
Vinyl Chloride	9.29E+01	2.45E+00	No (2)	1.00E+10	1.00E+10	25

Output generated 25JUL2018:15:53:31

Chemical	Lower Explosive Limit LEL (% by volume)	LEL Ref	Inhalation Unit Risk (ug/m <sup>3</sup> ) <sup>-1</sup>	IUR Ref	RfC (mg/m <sup>3</sup> )	RfC Ref	Mutagenic Indicator	Carcinogenic VISL TCR=1E-06 C <sub>la,c</sub> (μg/m <sup>3</sup> )	Noncarcinogenic VISL THQ=0.1 C <sub>la,nc</sub> (μg/m <sup>3</sup> )
Acetone	2.50	CRC89			3.09E+01	A	No		1.35E+04
Benzene	1.20	CRC89	7.80E-06	I	3.00E-02	I	No	1.57E+00	1.31E+01
Carbon Disulfide	1.30	CRC89			7.00E-01	I	No		3.07E+02
Chlorobenzene	1.30	CRC89			5.00E-02	P	No		2.19E+01
Chloroform			2.30E-05	I	9.77E-02	A	No	5.33E-01	4.28E+01
Dichlorobenzene, 1,2-	2.20	CRC89			2.00E-01	H	No		8.76E+01
Dichlorobenzene, 1,4-	1.80	YAWS	1.10E-05	C	8.00E-01	I	No	1.11E+00	3.50E+02
Dichloroethylene, 1,1-	6.50	CRC89			2.00E-01	I	No		8.76E+01
Dichloroethylene, 1,2-cis-	3.00	CRC89					No		
Dichloroethylene, 1,2-trans-	6.00	CRC89					No		
Ethylbenzene	0.80	CRC89	2.50E-06	C	1.00E+00	I	No	4.91E+00	4.38E+02
Methyl Ethyl Ketone (2-Butanone)	1.40	CRC89			5.00E+00	I	No		2.19E+03
Naphthalene	0.90	CRC89	3.40E-05	C	3.00E-03	I	No	3.61E-01	1.31E+00
Trichloro-1,2,2-trifluoroethane, 1,1,2-					5.00E+00	P	No		2.19E+03
Trichloroethylene	8.00	CRC89	4.10E-06	I	2.00E-03	I	Mut	2.99E+00	8.76E-01
Vinyl Chloride	3.60	CRC89	4.40E-06	I	1.00E-01	I	Mut	2.79E+00	4.38E+01

Chemical	CAS Number	Site Groundwater Concentration $C_{gw}$ (\(\mu\text{g/L}\))	Site Indoor Air Concentration $C_{ia}$ (\(\mu\text{g/m}^3\))	VI Carcinogenic Risk CR	VI Hazard HQ
Acetone	67-64-1	190	2.72E-01		2.01E-06
Benzene	71-43-2	33	7.49E+00	4.76E-06	5.70E-02
Carbon Disulfide	75-15-0	24	1.41E+01		4.61E-03
Chlorobenzene	108-90-7	4600	5.85E+02		2.67E+00
Chloroform	67-66-3	24	3.60E+00	6.75E-06	8.42E-03
Dichlorobenzene, 1,2-	95-50-1	6.3	4.95E-01		5.65E-04
Dichlorobenzene, 1,4-	106-46-7	9	8.87E-01	7.95E-07	2.53E-04
Dichloroethylene, 1,1-	75-35-4	6.7	7.15E+00		8.16E-03
Dichloroethylene, 1,2-cis-	156-59-2	27			
Dichloroethylene, 1,2-trans-	156-60-5	1.4			
Ethylbenzene	100-41-4	2	6.44E-01	1.31E-07	1.47E-04
Methyl Ethyl Ketone (2-Butanone)	78-93-3	50	1.16E-01		5.31E-06
Naphthalene	91-20-3	4	7.20E-02	1.99E-07	5.48E-03
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	2300	4.95E+04		2.26E+00
Trichloroethylene	79-01-6	230	9.26E+01	3.10E-05	1.06E+01
Vinyl Chloride	75-01-4	1.4	1.59E+00	5.71E-07	3.63E-03
<i>*Sum</i>				4.42E-05	1.56E+01

Chemical	Inhalation Unit Risk (ug/m <sup>3</sup> ) <sup>-1</sup>	IUR Ref	Chronic RfC (mg/m <sup>3</sup> )	RfC Ref	Temperature (°C)\ for Groundwater Vapor Concentration	Mutagen?
Acetone			3.09E+01	ATSDR	25	No
Benzene	7.80E-06	I	3.00E-02	IRIS	25	No
Carbon Disulfide			7.00E-01	IRIS	25	No
Chlorobenzene			5.00E-02	PPRTV	25	No
Chloroform	2.30E-05	I	9.77E-02	ATSDR	25	No
Dichlorobenzene, 1,2-			2.00E-01	HEAST	25	No
Dichlorobenzene, 1,4-	1.10E-05	C	8.00E-01	IRIS	25	No
Dichloroethylene, 1,1-			2.00E-01	IRIS	25	No
Dichloroethylene, 1,2-cis-					25	No
Dichloroethylene, 1,2-trans-					25	No
Ethylbenzene	2.50E-06	C	1.00E+00	IRIS	25	No
Methyl Ethyl Ketone (2-Butanone)			5.00E+00	IRIS	25	No
Naphthalene	3.40E-05	C	3.00E-03	IRIS	25	No
Trichloro-1,2,2-trifluoroethane, 1,1,2-			5.00E+00	PPRTV	25	No
Trichloroethylene	4.10E-06	I	2.00E-03	IRIS	25	Mut
Vinyl Chloride	4.40E-06	I	1.00E-01	IRIS	25	Mut
<i>*Sum</i>						

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	MW	MW Ref	Vapor Pressure VP (mm Hg)	VP Ref	S (mg/L)	S Ref	MCL (ug/L)
Acetone	67-64-1	Yes	Yes	58.08	PHYSPROP	2.32E+02	PHYSPROP	1.00E+06	PHYSPROP	
Benzene	71-43-2	Yes	Yes	78.12	PHYSPROP	9.48E+01	PHYSPROP	1.79E+03	PHYSPROP	5
Carbon Disulfide	75-15-0	Yes	Yes	76.14	PHYSPROP	3.59E+02	PHYSPROP	2.16E+03	PHYSPROP	
Chlorobenzene	108-90-7	Yes	Yes	112.56	PHYSPROP	1.20E+01	PHYSPROP	4.98E+02	PHYSPROP	100
Chloroform	67-66-3	Yes	Yes	119.38	PHYSPROP	1.97E+02	PHYSPROP	7.95E+03	PHYSPROP	80
Dichlorobenzene, 1,2-	95-50-1	Yes	Yes	147.00	PHYSPROP	1.36E+00	PHYSPROP	1.56E+02	PHYSPROP	600
Dichlorobenzene, 1,4-	106-46-7	Yes	Yes	147.00	PHYSPROP	1.74E+00	PHYSPROP	8.13E+01	PHYSPROP	75
Dichloroethylene, 1,1-	75-35-4	Yes	Yes	96.94	PHYSPROP	6.00E+02	PHYSPROP	2.42E+03	PHYSPROP	7
Dichloroethylene, 1,2-cis-	156-59-2	Yes	No	96.94	PHYSPROP	2.00E+02	PHYSPROP	6.41E+03	PHYSPROP	70
Dichloroethylene, 1,2-trans-	156-60-5	Yes	No	96.94	PHYSPROP	3.31E+02	EPI	4.52E+03	PHYSPROP	100
Ethylbenzene	100-41-4	Yes	Yes	106.17	PHYSPROP	9.60E+00	PHYSPROP	1.69E+02	PHYSPROP	700
Methyl Ethyl Ketone (2-Butanone)	78-93-3	Yes	Yes	72.11	PHYSPROP	9.06E+01	PHYSPROP	2.23E+05	PHYSPROP	
Naphthalene	91-20-3	Yes	Yes	128.18	PHYSPROP	8.50E-02	PHYSPROP	3.10E+01	PHYSPROP	
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	Yes	Yes	187.38	PHYSPROP	3.63E+02	PHYSPROP	1.70E+02	PHYSPROP	
Trichloroethylene	79-01-6	Yes	Yes	131.39	PHYSPROP	6.90E+01	PHYSPROP	1.28E+03	PHYSPROP	5
Vinyl Chloride	75-01-4	Yes	Yes	62.50	PHYSPROP	2.98E+03	EPI	8.80E+03	PHYSPROP	2



Chemical	HLC (atm-m <sup>3</sup> /mole)	Henry's Law Constant (unitless)	H' and HLC Ref	Henry's Law Constant Used in Calcs (unitless)	D <sub>la</sub> \ (cm <sup>2</sup> /s)	D <sub>la</sub> \ Ref	D <sub>lw</sub> \ (cm <sup>2</sup> /s)	D <sub>lw</sub> \ Ref	Normal Boiling Point T <sub>boil</sub> \ (K)
Acetone	3.50E-05	1.43E-03	PHYSPROP	1.43E-03	1.06E-01	WATER9 (U.S. EPA, 2001)	1.15E-05	WATER9 (U.S. EPA, 2001)	329.15
Benzene	5.55E-03	2.27E-01	PHYSPROP	2.27E-01	8.95E-02	WATER9 (U.S. EPA, 2001)	1.03E-05	WATER9 (U.S. EPA, 2001)	353.15
Carbon Disulfide	1.44E-02	5.89E-01	PHYSPROP	5.89E-01	1.06E-01	WATER9 (U.S. EPA, 2001)	1.30E-05	WATER9 (U.S. EPA, 2001)	319.15
Chlorobenzene	3.11E-03	1.27E-01	PHYSPROP	1.27E-01	7.21E-02	WATER9 (U.S. EPA, 2001)	9.48E-06	WATER9 (U.S. EPA, 2001)	404.85
Chloroform	3.67E-03	1.50E-01	PHYSPROP	1.50E-01	7.69E-02	WATER9 (U.S. EPA, 2001)	1.09E-05	WATER9 (U.S. EPA, 2001)	334.25
Dichlorobenzene, 1,2-	1.92E-03	7.85E-02	PHYSPROP	7.85E-02	5.62E-02	WATER9 (U.S. EPA, 2001)	8.92E-06	WATER9 (U.S. EPA, 2001)	453.15
Dichlorobenzene, 1,4-	2.41E-03	9.85E-02	PHYSPROP	9.85E-02	5.50E-02	WATER9 (U.S. EPA, 2001)	8.68E-06	WATER9 (U.S. EPA, 2001)	447.15
Dichloroethylene, 1,1-	2.61E-02	1.07E+00	PHYSPROP	1.07E+00	8.63E-02	WATER9 (U.S. EPA, 2001)	1.10E-05	WATER9 (U.S. EPA, 2001)	304.85
Dichloroethylene, 1,2-cis-	4.08E-03	1.67E-01	PHYSPROP	1.67E-01	8.84E-02	WATER9 (U.S. EPA, 2001)	1.13E-05	WATER9 (U.S. EPA, 2001)	333.25
Dichloroethylene, 1,2-trans-	9.38E-03	3.83E-01	PHYSPROP	3.83E-01	8.76E-02	WATER9 (U.S. EPA, 2001)	1.12E-05	WATER9 (U.S. EPA, 2001)	321.85
Ethylbenzene	7.88E-03	3.22E-01	PHYSPROP	3.22E-01	6.85E-02	WATER9 (U.S. EPA, 2001)	8.46E-06	WATER9 (U.S. EPA, 2001)	409.25
Methyl Ethyl Ketone (2-Butanone)	5.69E-05	2.33E-03	PHYSPROP	2.33E-03	9.14E-02	WATER9 (U.S. EPA, 2001)	1.02E-05	WATER9 (U.S. EPA, 2001)	352.65
Naphthalene	4.40E-04	1.80E-02	PHYSPROP	1.80E-02	6.05E-02	WATER9 (U.S. EPA, 2001)	8.38E-06	WATER9 (U.S. EPA, 2001)	491.05
Trichloro-1,2,2-trifluoroethane, 1,1,2-	5.26E-01	2.15E+01	EPI	2.15E+01	3.76E-02	WATER9 (U.S. EPA, 2001)	8.59E-06	WATER9 (U.S. EPA, 2001)	320.85
Trichloroethylene	9.85E-03	4.03E-01	PHYSPROP	4.03E-01	6.87E-02	WATER9 (U.S. EPA, 2001)	1.02E-05	WATER9 (U.S. EPA, 2001)	360.35
Vinyl Chloride	2.78E-02	1.14E+00	PHYSPROP	1.14E+00	1.07E-01	WATER9 (U.S. EPA, 2001)	1.20E-05	WATER9 (U.S. EPA, 2001)	259.85

Chemical	BP Ref	Critical Temperature $T_{crit}$ (K)	$T_{crit}$ Ref	Enthalpy of vaporization at the normal boiling point $\Delta H_{v,b}$ (cal/mol)	$\Delta H_{v,b}$ Ref	$K_{oc}$ (cm <sup>3</sup> /g)	$K_{oc}$ Ref	Lower Explosive Limit LEL (% by volume)	LEL Ref
Acetone	PHYSPROP	5.08E+02	CRC89	6955.07	CRC89	2.364	EPI	2.50	CRC89
Benzene	PHYSPROP	5.62E+02	CRC89	7342.26	CRC89	145.8	EPI	1.20	CRC89
Carbon Disulfide	PHYSPROP	5.52E+02	CRC89	6391.01	CRC89	21.73	EPI	1.30	CRC89
Chlorobenzene	PHYSPROP	6.32E+02	CRC89	8410.61	CRC89	233.9	EPI	1.30	CRC89
Chloroform	PHYSPROP	5.36E+02	CRC89	6988.00	Weast	31.82	EPI		
Dichlorobenzene, 1,2-	PHYSPROP	7.05E+02	YAWS	9478.97	CRC89	382.9	EPI	2.20	CRC89
Dichlorobenzene, 1,4-	PHYSPROP	6.69E+02	CRC89	9271.03	CRC89	375.3	EPI	1.80	YAWS
Dichloroethylene, 1,1-	PHYSPROP	4.82E+02	YAWS	6247.61	CRC89	31.82	EPI	6.50	CRC89
Dichloroethylene, 1,2-cis-	PHYSPROP	5.36E+02	CRC89	7217.97	CRC89	39.6	EPI	3.00	CRC89
Dichloroethylene, 1,2-trans-	PHYSPROP	5.16E+02	CRC89	6907.26	CRC89	39.6	EPI	6.00	CRC89
Ethylbenzene	PHYSPROP	6.17E+02	CRC89	8501.43	CRC89	446.1	EPI	0.80	CRC89
Methyl Ethyl Ketone (2-Butanone)	PHYSPROP	5.37E+02	CRC89	7480.88	CRC89	4.51	EPI	1.40	CRC89
Naphthalene	PHYSPROP	7.48E+02	CRC89	10373.00	Weast	1544	EPI	0.90	CRC89
Trichloro-1,2,2-trifluoroethane, 1,1,2-	PHYSPROP	4.87E+02	CRC89	6462.56	CRC	196.8	EPI		
Trichloroethylene	PHYSPROP	5.71E+02	YAWS	7505.00	Weast	60.7	EPI	8.00	CRC89
Vinyl Chloride	PHYSPROP	4.25E+02	CRC89	4971.32	CRC89	21.73	EPI	3.60	CRC89

## Site-specific VISL Results

### Commercial Equation Inputs

\* Inputted values different from Commercial defaults are highlighted.  
Output generated 25JUL2018:16:35:01

Variable	Commercial Air Default Value	Value
AF <sub>gw</sub> (Attenuation Factor Groundwater) unitless	0.001	0.001
AF <sub>ss</sub> (Attenuation Factor Sub-Slab) unitless	0.03	0.03
AT <sub>w</sub> (averaging time - composite worker)	365	365
ED <sub>w</sub> (exposure duration - composite worker) yr	25	25
EF <sub>w</sub> (exposure frequency - composite worker) day/yr	250	250
ET <sub>w</sub> (exposure time - composite worker) hr	8	8
THQ (target hazard quotient) unitless	0.1	0.1
LT (lifetime) yr	70	70
TR (target risk) unitless	1.0E-06	1.0E-06

Output generated 25JUL2018:16:35:01

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Soil Source? ( $C_{vp} > C_{ia,Target?}$ )	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Groundwater Source? ( $C_{hc} > C_{ia,Target?}$ )	Target Indoor Air Concentration (TCR=1E-06 or THQ=0.1) $MIN(C_{ia,c}, C_{ia,nc})$ ( $\mu\text{g}/\text{m}^3$ )	Toxicity Basis
Acetone	67-64-1	Yes	Yes	Yes	Yes	1.35E+04	NC
Benzene	71-43-2	Yes	Yes	Yes	Yes	1.57E+00	CA
Chlorobenzene	108-90-7	Yes	Yes	Yes	Yes	2.19E+01	NC
Chloroform	67-66-3	Yes	Yes	Yes	Yes	5.33E-01	CA
Cyclohexane	110-82-7	Yes	Yes	Yes	Yes	2.63E+03	NC
Dichlorobenzene, 1,2-	95-50-1	Yes	Yes	Yes	Yes	8.76E+01	NC
Dichlorobenzene, 1,3-	541-73-1	Yes	No	No Inhal. Tox. Info	No Inhal. Tox. Info		
Dichlorobenzene, 1,4-	106-46-7	Yes	Yes	Yes	Yes	1.11E+00	CA
Dichloroethane, 1,1-	75-34-3	Yes	Yes	Yes	Yes	7.67E+00	CA
Dichloroethane, 1,2-	107-06-2	Yes	Yes	Yes	Yes	4.72E-01	CA
Dichloroethylene, 1,1-	75-35-4	Yes	Yes	Yes	Yes	8.76E+01	NC
Dichloroethylene, 1,2-cis-	156-59-2	Yes	No	No Inhal. Tox. Info	No Inhal. Tox. Info		
Dichloroethylene, 1,2-trans-	156-60-5	Yes	No	No Inhal. Tox. Info	No Inhal. Tox. Info		
Ethylbenzene	100-41-4	Yes	Yes	Yes	Yes	4.91E+00	CA
Methyl tert-Butyl Ether (MTBE)	1634-04-4	Yes	Yes	Yes	Yes	4.72E+01	CA
Naphthalene	91-20-3	Yes	Yes	Yes	Yes	3.61E-01	CA
Tetrachloroethylene	127-18-4	Yes	Yes	Yes	Yes	1.75E+01	NC
Toluene	108-88-3	Yes	Yes	Yes	Yes	2.19E+03	NC
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	Yes	Yes	Yes	Yes	2.19E+03	NC
Trichloroethylene	79-01-6	Yes	Yes	Yes	Yes	8.76E-01	NC
Vinyl Chloride	75-01-4	Yes	Yes	Yes	Yes	2.79E+00	CA
Xylene, o-	95-47-6	Yes	Yes	Yes	Yes	4.38E+01	NC
Xylenes	1330-20-7	Yes	Yes	Yes	Yes	4.38E+01	NC

Output generated 25JUL2018:16:35:01

Chemical	Target Sub-Slab and Near-source Soil Gas Concentration (TCR=1E-06 or THQ=0.1) $C_{sg, Target}$ ( $\mu\text{g}/\text{m}^3$ )	Target Groundwater Concentration (TCR=1E-06 or THQ=0.1) $C_{gw, Target}$ ( $\mu\text{g}/\text{L}$ )	Is Target Groundwater Concentration < MCL? ( $C_{gw} < \text{MCL?}$ )	Pure Phase Vapor Concentration $C_{vp}$ ( $25^\circ\text{C}$ ) ( $\mu\text{g}/\text{m}^3$ )	Maximum Groundwater Vapor Concentration $C_{hc}$ ( $\mu\text{g}/\text{m}^3$ )	Temperature for Maximum Groundwater Vapor Concentration ( $^\circ\text{C}$ )	Lower Explosive Limit LEL (% by volume)
Acetone	4.51E+05	9.46E+06	--	7.25E+08	1.43E+09	25	2.50
Benzene	5.24E+01	6.93E+00	No (5)	3.98E+08	4.06E+08	25	1.20
Chlorobenzene	7.30E+02	1.72E+02	No (100)	7.26E+07	6.33E+07	25	1.30
Chloroform	1.78E+01	3.55E+00	Yes (80)	1.26E+09	1.19E+09	25	
Cyclohexane	8.76E+04	4.29E+02	--	4.39E+08	3.37E+08	25	1.30
Dichlorobenzene, 1,2-	2.92E+03	1.12E+03	No (600)	1.08E+07	1.22E+07	25	2.20
Dichlorobenzene, 1,3-				1.70E+07	1.34E+07	25	1.80
Dichlorobenzene, 1,4-	3.72E+01	1.13E+01	Yes (75)	1.38E+07	8.01E+06	25	1.80
Dichloroethane, 1,1-	2.56E+02	3.34E+01	--	1.21E+09	1.16E+09	25	5.40
Dichloroethane, 1,2-	1.57E+01	9.78E+00	No (5)	4.20E+08	4.15E+08	25	6.20
Dichloroethylene, 1,1-	2.92E+03	8.21E+01	No (7)	3.13E+09	2.58E+09	25	6.50
Dichloroethylene, 1,2-cis-				1.04E+09	1.07E+09	25	3.00
Dichloroethylene, 1,2-trans-				1.73E+09	1.73E+09	25	6.00
Ethylbenzene	1.64E+02	1.52E+01	Yes (700)	5.48E+07	5.44E+07	25	0.80
Methyl tert-Butyl Ether (MTBE)	1.57E+03	1.97E+03	--	1.19E+09	1.22E+09	25	2.00
Naphthalene	1.20E+01	2.01E+01	--	5.86E+05	5.58E+05	25	0.90
Tetrachloroethylene	5.84E+02	2.42E+01	No (5)	1.65E+08	1.49E+08	25	
Toluene	7.30E+04	8.07E+03	No (1000)	1.41E+08	1.43E+08	25	1.10
Trichloro-1,2,2-trifluoroethane, 1,1,2-	7.30E+04	1.02E+02	--	3.65E+09	3.66E+09	25	
Trichloroethylene	2.92E+01	2.18E+00	Yes (5)	4.88E+08	5.15E+08	25	8.00
Vinyl Chloride	9.29E+01	2.45E+00	No (2)	1.00E+10	1.00E+10	25	3.60
Xylene, o-	1.46E+03	2.07E+02	--	3.77E+07	3.77E+07	25	0.90
Xylenes	1.46E+03	1.62E+02	Yes (10000)	4.56E+07	2.87E+07	25	

Output generated 25JUL2018:16:35:01

Chemical	LEL Ref	Inhalation Unit Risk ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	IUR Ref	RfC ( $\text{mg}/\text{m}^3$ )	RfC Ref	Mutagenic Indicator	Carcinogenic VISL TCR=1E-06 $C_{\text{la,c}}$ ( $\mu\text{g}/\text{m}^3$ )	Noncarcinogenic VISL THQ=0.1 $C_{\text{la,nc}}$ ( $\mu\text{g}/\text{m}^3$ )
Acetone	U			3.09E+01	U	No		1.35E+04
Benzene	U	7.80E-06	U	3.00E-02	U	No	1.57E+00	1.31E+01
Chlorobenzene	U			5.00E-02	U	No		2.19E+01
Chloroform		2.30E-05	U	9.77E-02	U	No	5.33E-01	4.28E+01
Cyclohexane	U			6.00E+00	U	No		2.63E+03
Dichlorobenzene, 1,2-	U			2.00E-01	U	No		8.76E+01
Dichlorobenzene, 1,3-	U					No		
Dichlorobenzene, 1,4-	U	1.10E-05	U	8.00E-01	U	No	1.11E+00	3.50E+02
Dichloroethane, 1,1-	U	1.60E-06	U			No	7.67E+00	
Dichloroethane, 1,2-	U	2.60E-05	U	7.00E-03	U	No	4.72E-01	3.07E+00
Dichloroethylene, 1,1-	U			2.00E-01	U	No		8.76E+01
Dichloroethylene, 1,2-cis-	U					No		
Dichloroethylene, 1,2-trans-	U					No		
Ethylbenzene	U	2.50E-06	U	1.00E+00	U	No	4.91E+00	4.38E+02
Methyl tert-Butyl Ether (MTBE)	U	2.60E-07	U	3.00E+00	U	No	4.72E+01	1.31E+03
Naphthalene	U	3.40E-05	U	3.00E-03	U	No	3.61E-01	1.31E+00
Tetrachloroethylene		2.60E-07	U	4.00E-02	U	No	4.72E+01	1.75E+01
Toluene	U			5.00E+00	U	No		2.19E+03
Trichloro-1,2,2-trifluoroethane, 1,1,2-				5.00E+00	U	No		2.19E+03
Trichloroethylene	U	4.10E-06	U	2.00E-03	U	Mut	2.99E+00	8.76E-01
Vinyl Chloride	U	4.40E-06	U	1.00E-01	U	Mut	2.79E+00	4.38E+01
Xylene, o-	U			1.00E-01	U	No		4.38E+01
Xylenes				1.00E-01	U	No		4.38E+01

Chemical	CAS Number	Site Groundwater Concentration $C_{gw}$ (\(\mu\text{g/L}\))	Site Indoor Air Concentration $C_{ia}$ (\(\mu\text{g/m}^3\))	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk (\(\text{ug/m}^3\)) <sup>-1</sup>	IUR Ref
Acetone	67-64-1	110	1.57E-01		1.16E-06		
Benzene	71-43-2	240	5.45E+01	3.46E-05	4.14E-01	7.80E-06	U
Chlorobenzene	108-90-7	79	1.00E+01		4.59E-02		
Chloroform	67-66-3	3	4.50E-01	8.44E-07	1.05E-03	2.30E-05	U
Cyclohexane	110-82-7	1.2	7.36E+00		2.80E-04		
Dichlorobenzene, 1,2-	95-50-1	920	7.22E+01		8.24E-02		
Dichlorobenzene, 1,3-	541-73-1	8					
Dichlorobenzene, 1,4-	106-46-7	100	9.85E+00	8.84E-06	2.81E-03	1.10E-05	U
Dichloroethane, 1,1-	75-34-3	16	3.68E+00	4.80E-07		1.60E-06	U
Dichloroethane, 1,2-	107-06-2	1.1	5.31E-02	1.13E-07	1.73E-03	2.60E-05	U
Dichloroethylene, 1,1-	75-35-4	5.3	5.66E+00		6.46E-03		
Dichloroethylene, 1,2-cis-	156-59-2	600					
Dichloroethylene, 1,2-trans-	156-60-5	3.7					
Ethylbenzene	100-41-4	4.8	1.55E+00	3.15E-07	3.53E-04	2.50E-06	U
Methyl tert-Butyl Ether (MTBE)	1634-04-4	1.1	2.64E-02	5.60E-10	2.01E-06	2.60E-07	U
Naphthalene	91-20-3	4	7.20E-02	1.99E-07	5.48E-03	3.40E-05	U
Tetrachloroethylene	127-18-4	230	1.66E+02	3.53E-06	9.50E-01	2.60E-07	U
Toluene	108-88-3	5.3	1.44E+00		6.57E-05		
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	960	2.06E+04		9.43E-01		
Trichloroethylene	79-01-6	56	2.26E+01	7.54E-06	2.57E+00	4.10E-06	U
Vinyl Chloride	75-01-4	110	1.25E+02	4.49E-05	2.85E-01	4.40E-06	U
Xylene, o-	95-47-6	13	2.75E+00		6.29E-03		
Xylenes	1330-20-7	13	3.52E+00		8.05E-03		
<i>*Sum</i>				1.01E-04	5.33E+00		

Chemical	Chronic RfC (mg/m <sup>3</sup> )	RfC Ref	Temperature (°C)\ for Groundwater Vapor Concentration	Mutagen?
Acetone	3.09E+01	U	25	No
Benzene	3.00E-02	U	25	No
Chlorobenzene	5.00E-02	U	25	No
Chloroform	9.77E-02	U	25	No
Cyclohexane	6.00E+00	U	25	No
Dichlorobenzene, 1,2-	2.00E-01	U	25	No
Dichlorobenzene, 1,3-			25	No
Dichlorobenzene, 1,4-	8.00E-01	U	25	No
Dichloroethane, 1,1-			25	No
Dichloroethane, 1,2-	7.00E-03	U	25	No
Dichloroethylene, 1,1-	2.00E-01	U	25	No
Dichloroethylene, 1,2-cis-			25	No
Dichloroethylene, 1,2-trans-			25	No
Ethylbenzene	1.00E+00	U	25	No
Methyl tert-Butyl Ether (MTBE)	3.00E+00	U	25	No
Naphthalene	3.00E-03	U	25	No
Tetrachloroethylene	4.00E-02	U	25	No
Toluene	5.00E+00	U	25	No
Trichloro-1,2,2-trifluoroethane, 1,1,2-	5.00E+00	U	25	No
Trichloroethylene	2.00E-03	U	25	Mut
Vinyl Chloride	1.00E-01	U	25	Mut
Xylene, o-	1.00E-01	U	25	No
Xylenes	1.00E-01	U	25	No
<i>*Sum</i>				



Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	MW	MW Ref	Vapor Pressure VP (mm Hg)	VP Ref	S (mg/L)	S Ref	MCL (ug/L)
Acetone	67-64-1	Yes	Yes	58.08	U	2.32E+02	U	1.00E+06	U	
Benzene	71-43-2	Yes	Yes	78.12	U	9.48E+01	U	1.79E+03	U	5
Chlorobenzene	108-90-7	Yes	Yes	112.56	U	1.20E+01	U	4.98E+02	U	100
Chloroform	67-66-3	Yes	Yes	119.38	U	1.97E+02	U	7.95E+03	U	80
Cyclohexane	110-82-7	Yes	Yes	84.16	U	9.69E+01	U	5.50E+01	U	
Dichlorobenzene, 1,2-	95-50-1	Yes	Yes	147.00	U	1.36E+00	U	1.56E+02	U	600
Dichlorobenzene, 1,3-	541-73-1	Yes	No	147.00	U	2.15E+00	U	1.25E+02	U	
Dichlorobenzene, 1,4-	106-46-7	Yes	Yes	147.00	U	1.74E+00	U	8.13E+01	U	75
Dichloroethane, 1,1-	75-34-3	Yes	Yes	98.96	U	2.27E+02	U	5.04E+03	U	
Dichloroethane, 1,2-	107-06-2	Yes	Yes	98.96	U	7.89E+01	U	8.60E+03	U	5
Dichloroethylene, 1,1-	75-35-4	Yes	Yes	96.94	U	6.00E+02	U	2.42E+03	U	7
Dichloroethylene, 1,2-cis-	156-59-2	Yes	No	96.94	U	2.00E+02	U	6.41E+03	U	70
Dichloroethylene, 1,2-trans-	156-60-5	Yes	No	96.94	U	3.31E+02	U	4.52E+03	U	100
Ethylbenzene	100-41-4	Yes	Yes	106.17	U	9.60E+00	U	1.69E+02	U	700
Methyl tert-Butyl Ether (MTBE)	1634-04-4	Yes	Yes	88.15	U	2.50E+02	U	5.10E+04	U	
Naphthalene	91-20-3	Yes	Yes	128.18	U	8.50E-02	U	3.10E+01	U	
Tetrachloroethylene	127-18-4	Yes	Yes	165.83	U	1.85E+01	U	2.06E+02	U	5
Toluene	108-88-3	Yes	Yes	92.14	U	2.84E+01	U	5.26E+02	U	1000
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	Yes	Yes	187.38	U	3.62E+02	U	1.70E+02	U	
Trichloroethylene	79-01-6	Yes	Yes	131.39	U	6.90E+01	U	1.28E+03	U	5
Vinyl Chloride	75-01-4	Yes	Yes	62.50	U	2.98E+03	U	8.80E+03	U	2
Xylene, o-	95-47-6	Yes	Yes	106.17	U	6.61E+00	U	1.78E+02	U	
Xylenes	1330-20-7	Yes	Yes	106.17	U	7.99E+00	U	1.06E+02	U	10000

Chemical	HLC (atm-m <sup>3</sup> /mole)	Henry's Law Constant (unitless)	H <sup>+</sup> and HLC Ref	Henry's Law Constant Used in Calcs (unitless)	D <sub>ia</sub> \ (cm <sup>2</sup> /s)	D <sub>ia</sub> \ Ref	D <sub>iw</sub> \ (cm <sup>2</sup> /s)	D <sub>iw</sub> \ Ref	Normal Boiling Point T <sub>boil</sub> \ (K)	BP Ref
Acetone	3.50E-05	1.43E-03	U	1.43E-03	1.06E-01	U	1.15E-05	U	329.15	U
Benzene	5.55E-03	2.27E-01	U	2.27E-01	8.95E-02	U	1.03E-05	U	353.15	U
Chlorobenzene	3.11E-03	1.27E-01	U	1.27E-01	7.21E-02	U	9.48E-06	U	405.15	U
Chloroform	3.67E-03	1.50E-01	U	1.50E-01	7.69E-02	U	1.09E-05	U	334.25	U
Cyclohexane	1.50E-01	6.13E+00	U	6.13E+00	8.00E-02	U	9.11E-06	U	353.85	U
Dichlorobenzene, 1,2-	1.92E-03	7.85E-02	U	7.85E-02	5.62E-02	U	8.92E-06	U	453.15	U
Dichlorobenzene, 1,3-	2.63E-03	1.08E-01	U	1.08E-01	5.58E-02	U	8.85E-06	U	446.15	U
Dichlorobenzene, 1,4-	2.41E-03	9.85E-02	U	9.85E-02	5.50E-02	U	8.68E-06	U	447.15	U
Dichloroethane, 1,1-	5.62E-03	2.30E-01	U	2.30E-01	8.36E-02	U	1.06E-05	U	330.55	U
Dichloroethane, 1,2-	1.18E-03	4.82E-02	U	4.82E-02	8.57E-02	U	1.10E-05	U	356.65	U
Dichloroethylene, 1,1-	2.61E-02	1.07E+00	U	1.07E+00	8.63E-02	U	1.10E-05	U	304.85	U
Dichloroethylene, 1,2-cis-	4.08E-03	1.67E-01	U	1.67E-01	8.84E-02	U	1.13E-05	U	333.25	U
Dichloroethylene, 1,2-trans-	9.38E-03	3.83E-01	U	3.83E-01	8.76E-02	U	1.12E-05	U	321.85	U
Ethylbenzene	7.88E-03	3.22E-01	U	3.22E-01	6.85E-02	U	8.46E-06	U	409.15	U
Methyl tert-Butyl Ether (MTBE)	5.87E-04	2.40E-02	U	2.40E-02	7.53E-02	U	8.59E-06	U	328.15	U
Naphthalene	4.40E-04	1.80E-02	U	1.80E-02	6.05E-02	U	8.38E-06	U	491.15	U
Tetrachloroethylene	1.77E-02	7.24E-01	U	7.24E-01	5.05E-02	U	9.46E-06	U	394.15	U
Toluene	6.64E-03	2.71E-01	U	2.71E-01	7.78E-02	U	9.20E-06	U	384.15	U
Trichloro-1,2,2-trifluoroethane, 1,1,2-	5.26E-01	2.15E+01	U	2.15E+01	3.76E-02	U	8.59E-06	U	320.85	U
Trichloroethylene	9.85E-03	4.03E-01	U	4.03E-01	6.87E-02	U	1.02E-05	U	360.35	U
Vinyl Chloride	2.78E-02	1.14E+00	U	1.14E+00	1.07E-01	U	1.20E-05	U	259.85	U
Xylene, o-	5.18E-03	2.12E-01	U	2.12E-01	6.89E-02	U	8.53E-06	U	417.15	U
Xylenes	6.63E-03	2.71E-01	U	2.71E-01	6.85E-02	U	8.46E-06	U	411.15	U

Chemical	Critical Temperature $T_{crit}$ \ (K)	$T_{crit}$ \ Ref	Enthalpy of vaporization at the normal boiling point $\Delta H_{v,b}$ \ (cal/mol)	$\Delta H_{v,b}$ \ Ref	$K_{oc}$ \ (cm <sup>3</sup> /g)	$K_{oc}$ \ Ref	Lower Explosive Limit LEL (% by volume)	LEL Ref
Acetone	5.08E+02	U	6960.00	U	2.36	U	2.50	U
Benzene	5.62E+02	U	7340.00	U	146	U	1.20	U
Chlorobenzene	6.32E+02	U	8410.00	U	234	U	1.30	U
Chloroform	5.36E+02	U	6990.00	U	31.8	U		
Cyclohexane	5.53E+02	U	7160.00	U	146	U	1.30	U
Dichlorobenzene, 1,2-	7.05E+02	U	9480.00	U	383	U	2.20	U
Dichlorobenzene, 1,3-	6.86E+02	U	9230.00	U	375	U	1.80	U
Dichlorobenzene, 1,4-	6.69E+02	U	9270.00	U	375	U	1.80	U
Dichloroethane, 1,1-	5.23E+02	U	6900.00	U	31.8	U	5.40	U
Dichloroethane, 1,2-	5.62E+02	U	7640.00	U	39.6	U	6.20	U
Dichloroethylene, 1,1-	4.82E+02	U	6250.00	U	31.8	U	6.50	U
Dichloroethylene, 1,2-cis-	5.36E+02	U	7220.00	U	39.6	U	3.00	U
Dichloroethylene, 1,2-trans-	5.16E+02	U	6910.00	U	39.6	U	6.00	U
Ethylbenzene	6.17E+02	U	8500.00	U	446	U	0.80	U
Methyl tert-Butyl Ether (MTBE)	4.97E+02	U	6680.00	U	11.6	U	2.00	U
Naphthalene	7.48E+02	U	10400.00	U	1540	U	0.90	U
Tetrachloroethylene	6.20E+02	U	8290.00	U	94.9	U		
Toluene	5.92E+02	U	7930.00	U	234	U	1.10	U
Trichloro-1,2,2-trifluoroethane, 1,1,2-	4.87E+02	U	6460.00	U	197	U		
Trichloroethylene	5.71E+02	U	7500.00	U	60.7	U	8.00	U
Vinyl Chloride	4.25E+02	U	4970.00	U	21.7	U	3.60	U
Xylene, o-	6.30E+02	U	8660.00	U	383	U	0.90	U
Xylenes	6.20E+02	U	8520.00	U	383	U		

## Site-specific VISL Results

### Commercial Equation Inputs

\* Inputted values different from Commercial defaults are highlighted.  
Output generated 25JUL2018:12:44:24

Variable	Commercial Air Default Value	Value
AF <sub>gw</sub> (Attenuation Factor Groundwater) unitless	0.001	0.001
AF <sub>ss</sub> (Attenuation Factor Sub-Slab) unitless	0.03	0.03
AT <sub>w</sub> (averaging time - composite worker)	365	365
ED <sub>w</sub> (exposure duration - composite worker) yr	25	25
EF <sub>w</sub> (exposure frequency - composite worker) day/yr	250	250
ET <sub>w</sub> (exposure time - composite worker) hr	8	8
THQ (target hazard quotient) unitless	0.1	0.1
LT (lifetime) yr	70	70
TR (target risk) unitless	1.0E-06	1.0E-06

Output generated 25JUL2018:12:44:24

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Soil Source? ( $C_{vp} > C_{ia}, \text{Target?}$ )	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Groundwater Source? ( $C_{hc} > C_{ia}, \text{Target?}$ )	Target Indoor Air Concentration (TCR=1E-06 or THQ=0.1) $\text{MIN}(C_{ia,c}, C_{ia,nc})$ ( $\mu\text{g}/\text{m}^3$ )	Toxicity Basis
Chloroform	67-66-3	Yes	Yes	Yes	Yes	5.33E-01	CA

Chemical	Target Sub-Slab and Near-source Soil Gas Concentration (TCR=1E-06 or THQ=0.1) $C_{sg}, \text{Target}$ ( $\mu\text{g}/\text{m}^3$ )	Target Groundwater Concentration (TCR=1E-06 or THQ=0.1) $C_{gw}, \text{Target}$ ( $\mu\text{g}/\text{L}$ )	Is Target Groundwater Concentration < MCL? ( $C_{gw} < \text{MCL?}$ )	Pure Phase Vapor Concentration $C_{vp}$ (25 °C) ( $\mu\text{g}/\text{m}^3$ )	Maximum Groundwater Vapor Concentration $C_{hc}$ ( $\mu\text{g}/\text{m}^3$ )	Temperature for Maximum Groundwater Vapor Concentration (°C)	Lower Explosive Limit LEL (% by volume)	LEL Ref
Chloroform	1.78E+01	3.55E+00	Yes (80)	1.26E+09	1.19E+09	25		

Chemical	Inhalation Unit Risk ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	IUR Ref	RfC (mg/m <sup>3</sup> )	RfC Ref	Mutagenic Indicator	Carcinogenic VISL TCR=1E-06 $C_{ia,c}$ ( $\mu\text{g}/\text{m}^3$ )	Noncarcinogenic VISL THQ=0.1 $C_{ia,nc}$ ( $\mu\text{g}/\text{m}^3$ )
Chloroform	2.30E-05	U	9.77E-02	U	No	5.33E-01	4.28E+01

Chemical	CAS Number	Site Groundwater Concentration $C_{gw}$ ( $\mu\text{g/L}$ )	Site Indoor Air Concentration $C_{ia}$ ( $\mu\text{g/m}^3$ )	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk ( $\text{ug/m}^3$ ) <sup>-1</sup>	IUR Ref	Chronic RfC ( $\text{mg/m}^3$ )	RfC Ref	Temperature (°C)\ for Groundwater Vapor Concentration	Mutagen?
Chloroform	67-66-3	0.2	3.00E-02	5.63E-08	7.01E-05	2.30E-05	U	9.77E-02	U	25	No
*Sum				5.63E-08	7.01E-05						

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	MW	MW Ref	Vapor Pressure VP (mm Hg)	VP Ref	S (mg/L)	S Ref	MCL (ug/L)	HLC (atm-m³/mole)
Chloroform	67-66-3	Yes	Yes	119.38	U	1.97E+02	U	7.95E+03	U	80	3.67E-03

Chemical	Henry's Law Constant (unitless)	H' and HLC Ref	Henry's Law Constant Used in Calcs (unitless)	D <sub>ia</sub> \ (cm²/s)	D <sub>ia</sub> \ Ref	D <sub>iw</sub> \ (cm²/s)	D <sub>iw</sub> \ Ref	Normal Boiling Point T <sub>boil</sub> \ (K)	BP Ref	Critical Temperature T <sub>crit</sub> \ (K)	T <sub>crit</sub> \ Ref
Chloroform	1.50E-01	U	1.50E-01	7.69E-02	U	1.09E-05	U	334.25	U	5.36E+02	U

Chemical	Enthalpy of vaporization at the normal boiling point ΔH <sub>v,b</sub> \ (cal/mol)	ΔH <sub>v,b</sub> \ Ref	K <sub>oc</sub> \ (cm²/g)	K <sub>oc</sub> \ Ref	Lower Explosive Limit LEL (% by volume)	LEL Ref
Chloroform	6990.00	U	31.8	U		